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Proceedings of the

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Atlantic City, N. J.

Sept. 27 to Oct. 1, 1915

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A. O. BACKERT

Secretary

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R. A. Bull

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American Foundrymen's Association

Summary of the Proceedings of the Twentieth Annual Meeting,

Atlantic City, N. J., Sept. 27 to Oct. 1, 1915

The Twentieth Annual Meeting of the American Foundrymen's Association was held at Atlantic City, N. J., from Sept. 27 to Oct 1, 1915, with professional sessions in the Greek Temple, on Young's Million Dollar Pier, and also at the Hotel Traymore. Monday, Sept. 27, was devoted entirely to registration, the technical sessions having commenced Tuesday morning, Sept. 28.

Opening Session

Tuesday, Sept. 28, 10 *A. M., Young's Million Dollar Pier*

President R. A. Bull in the chair.

Joint session, American Foundrymen's Association and American Institute of Metals.

Henry A. Carpenter, vice president of the American Foundrymen's Association, on behalf of the foundrymen of the east, delivered the address of welcome and response was made by J. P. Pero, Missouri Malleable Iron Co., East St. Louis, Ill.

Motion was made by Major Joseph T. Speer that a committee be appointed to draft suitable resolutions on the deaths of Thomas D. West and E. H. Mumford. The chairman then appointed the following committee: Dr. Richard Moldenke, chairman; Thomas Devlin and Paul Kreuzpointner.

The chairman announced the appointment of the Nominating Committee, as follows: J. S. Seaman, chairman; L. L. Anthes, Henry A. Carpenter, A. E. Howell and Major Jos. T. Speer.

The Committee on Resolutions, also appointed by the chair, consisted of Benj. D. Fuller, chairman; J. J. Wilson and W. B. Robinson.

In the absence of A. W. Gregg, chairman, Bucyrus Co., South Milwaukee, Wis., the report of the A. F. A. Committee on Safety was presented by the secretary.

This was followed by the report of the A. F. A. Committee on Industrial Education, by Frank M. Leavitt, chairman, University of Chicago, Chicago, Ill.

"A Preliminary Report on Molding Sands" was the subject of a paper presented by C. P. Karr, Associate Physicist United States Bureau of Standards, Washington, D. C.

This was followed by an illustrated address entitled "Tests of Lenses for Foundry Goggles", by F. W. King, Julius King Optical Co., New York.

Second Session

Tuesday, Sept. 28, 2:30 *P. M., Young's Million Dollar Pier*

President R. A. Bull in the chair.

The following papers and reports were presented:

"Notes on Applications and Characteristics of Cores in Modern Molding", by R. A. Bull, Commonwealth Steel Co., Granite City, Ill.

"Albany Molding Sands", an illustrated address, by D. H. Newland, Associate State Geologist, Albany, N. Y.

"Reclaiming Molding Sand", by W. M. Saunders and H. B. Hanley, Providence, R. I.

"Report of A. F. A. Committee on Standard Specifications for Foundry Scrap", by S. D. Sleeth, chairman, Westinghouse Air Brake Co., Wilmerding, Pa.

"Foundations for Jar-ramming Machines", by E. S. Carman, Osborn Mfg. Co., Cleveland. This address was illustrated by lantern slides.

"The History and Development of the Molding Machine with Sidelights on Latter-Day Practice", by J. J. Wilson, Cadillac Motor Car Co., Detroit, and A. O. Backert, Cleveland. This paper was illustrated by lantern slides.

"Patternmaking for Molding Machine Work", by E. I. Chase, Cadillac Motor Car Co., Detroit.

"The Relation of the Foundry Foreman to His Employer", by S. V. Blair, Rushville, Ind.

Third Session

Wednesday, Sept. 29, 10 A. M., Young's Million Dollar Pier

President R. A. Bull in the chair.

The following papers and addresses were presented:

"Organization in the Foundry of the University of Illinois Shop Laboratories", by R. A. Kennedy and J. H. Hogue, Instructors, University of Illinois, Urbana, Ill. This paper was illustrated by lantern slides.

"Comments on the Tendencies of Merchant Pig Iron", by Oliver J. Abell, *The Iron Age,* Chicago.

"Scientific Management and Its Relation to the Foundry Industry", by H. K. Hathaway, Tabor Mfg. Co., Philadelphia.

"The Modern Foundry Advance", by Dr. Richard Moldenke, consulting metallurgical engineer, Watchung, N. J.

Proceedings and Recommendations of the A. F. A. Cost Committee, by Benj. D. Fuller, chairman, Westinghouse Electric & Mfg. Co., Cleveland.

A suggestion was made by Secretary A. O. Backert, that a committee be appointed to carry out the recommendation made by the Cost Committee, and a motion, duly seconded, was adopted, providing for the appointment of a committee, which shall in conjunction with the secretary, correspond with the members of the American Foundrymen's Association with a view of carrying out the suggested recommendations of the Cost Committee. It was announced by the chairman that this committee shall consist of the members of the Cost Committee, as constituted.

Fourth Session

Wednesday, Sept. 29, 2:30 P. M., Young's Million Dollar Pier

Vice President Benj. D. Fuller in the chair.

The following papers and addresses were read and discussed:

"Structural or Mechanical Theory of the Effect of Rust on Cast Iron and Wrought Iron and Steel", by R. C. McWayne, publisher *The Fire Engineer,* and H. Y. Carson, Central Foundry Co., New York.

"Fuel Oil Cupolas", by Bradley Stoughton, consulting metallurgical engineer, New York.

Report of A. F. A. Committee on Standard Specifications for Gray Iron Castings, by W. P. Putnam, chairman, Detroit Testing Laboratory, Detroit.

"Inspection of Automobile Castings", by C. B. Wilson, Wilson Foundry & Machine Co., Pontiac, Mich.

"Pouring Systems for Gray Iron Foundries", by H. Cole Estep, associate editor, *The Foundry,* Cleveland.

Report of A. F. A. Committee on Standard Methods for Analyzing Coke, by H. E. Diller, chairman, General Electric Co., Erie, Pa.

"Defects Common to Gray Iron Castings—Their Causes and Remedies", by Herbert M. Ramp, Elmwood Casting Co., Cincinnati, was read by title in the absence of the author.

"Functions of Sand Binders", by H. M. Lane, foundry engineer, Detroit, which was to have been read at the opening session, Tuesday morning, was read by title in the continued absence of the author.

An interesting demonstration of the Brinell hardness testing machine and Shore scleroscope was made by W. D. Putnam, Detroit Testing Laboratory, Detroit.

Fifth Session

Annual Business Session, Wednesday, Sept. 28, 8:30 P. M., Hotel Traymore

President R. A. Bull in the chair.

The meeting was opened by the presentation of the annual address by the President, R. A. Bull.

This was followed by the report of the Secretary-Treasurer, A. O. Backert; the report of the Executive Board and the report of the auditor, Ernst & Ernst, Cleveland.

Officers for the ensuing year were elected as follows:

President, R. A. Bull, Commonwealth Steel Co., Granite City, Ill.
Senior Vice President, J. P. Pero, Missouri Malleable Iron Co., East St. Louis, Ill.
Vice President, Henry A. Carpenter, General Fire Extinguisher Co., Providence, R. I.
Vice President, S. B. Chadsey, Massey-Harris Co., Ltd., Toronto, Ont.
Vice President, Alex T. Drysdale, U. S. Cast Iron Pipe & Foundry Co., Burlington, N. J.
Vice President, H. E. Field, Wheeling Mold & Foundry Co., Wheeling, W. Va.
Vice President, Benj. D. Fuller, Westinghouse Electric & Mfg. Co., Cleveland.
Vice President, W. A. Janssen, Bettendorf Co., Davenport, Iowa.
Vice President, H. B. Swan, Cadillac Motor Car Co., Detroit.
Vice President, A. H. Thomas, Buckeye Steel Castings Co., Columbus, Ohio.
Vice President, Walter Wood, R. D. Wood & Co., Philadelphia.
Secretary-Treasurer, A. O. Backert, Cleveland.

Upon motion by J. S. Seaman, Seaman-Sleeth Co., Pittsburgh, which was duly seconded and adopted, the salary of the Secretary-Treasurer was increased from $1,200 to $1,800 per year, dating from October 1, 1915.

Upon motion by J. S. Seaman, Seaman-Sleeth Co., Pittsburgh, which was duly seconded, President R. A. Bull was elected to honorary membership.

Resolutions upon the deaths of Thomas D. West and E. H. Mumford, were presented by Dr. Richard Moldenke, chairman of the special committee appointed for this purpose, and these appear elsewhere in this volume.

It was suggested that all recommendations made in the annual address of the president and other suggestions contained in the discussions of the evening, be referred to the Executive Committee with full power to act, and when placed in the form of a motion, was duly seconded and adopted.

Sixth Session

Thursday, Sept. 30, 10 *A. M., Young's Million Dollar Pier*

President R. A. Bull in the chair.

The following papers were read and discussed:

"Dynamic Properties of Steel Employed in the Manufacture of Castings of Various Types", by J. Lloyd Uhler, Union Steel Casting Co., Pittsburgh.

"The Particular Application of the Converter in the Manufacture of Steel Castings", by C. S. Koch, Fort Pitt Steel Casting Co., McKeesport, Pa.

"Notes on Electric Furnace Construction and Operation in the Steel Foundry", by James H. Gray, United States Steel Corporation, New York.

Seventh Session

Thursday, Sept. 30, 2:30 P. M., Young's Million Dollar Pier

President R. A. Bull in the chair.

The following papers and reports were read and discussed:

"Open-Hearth Furnace Checker Design", by W. A. Janssen, Bettendorf Co., Davenport, Ia.

The report of the A. F. A. Committee on Specifications for Steel Castings was read by W. C. Hamilton, Chairman, American Steel Foundries, Granite City, Ill.

Motion was made by H. E. Field, Wheeling Mold & Foundry Co., that the recommendations contained in the report of the committee be tabled, and after having been duly seconded, was carried.

The question of discontinuing this committee was discussed and it was suggested that the decision be left with the Executive Board. A motion embodying this suggestion was not supported.

"The Electric Arc in the Foundry", by Robt. L. Kinkead, Lincoln Electric Co., Cleveland.

"Causes of Shrinkage Cracks in Steel Castings", by Wm. R. Bossinger, Marion Steam Shovel Co., Marion, Ohio. In the absence of the author, this paper was presented in abstract by the secretary.

Report of the A. F. A. Committee on Steel Foundry Standards, by Dudley Shoemaker, Chairman, American Steel Foundries, Indiana Harbor, Ind., and R. A. Bull, Commonwealth Steel Co., Granite City, Ill.

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Eighth Session

Thursday, Sept. 30, 10 *A. M., Young's Million Dollar Pier*

Vice President J. P. Pero in the chair.

The following papers and reports were read and discussed:

"An Outline to Illustrate the Interdependent Relationship of the Variable Factors in Malleable Iron Production", by L. E. Gilmore, Baltimore Malleable & Steel Co., Baltimore.

"Standardization of Air Furnace Practice", by A. L. Pollard, Johnston Harvester Co., Batavia, N. Y.

"Some Remarks Regarding the Permmisable Phosphorus Limit in Malleable Iron Castings", by Prof. Enrique Touceda, Renssalaer Polytechnic Institute, Albany, N. Y.

Report of the A. F. A. Committee on Standard Specifications for Malleable Iron Castings, by Enrique Touceda, Chairman, Albany, N. Y.

Upon motion by W. D. Putnam, Detroit Testing Laboratory, Detroit, the specifications were approved as submitted by the committee, and it was also moved and adopted that the committee consider the preparation of specifications applying to special grades of malleable work.

"The Evolution of the Malleable Iron Process", by J. P. Pero and J. C. Nulsen, Missouri Malleable Iron Co., East St. Louis, Ill.

"Coal—Its Origin and Use in Air Furnace", by F. Van O'Linda, Consolidation Coal Co., Chicago, in the absence of the author was read by title.

Ninth Session

Friday, Oct. 1, 10 *A. M., Young's Million Dollar Pier*

President R. A. Bull in the chair.

Benj. D. Fuller, chairman of the Committee on Resolutions, presented the following:

Resolved: That the American Foundrymen's Association, assembled in its twentieth convention at Atlantic City, N. J., wishes to express its appreciation of the faithful and thorough work of those who, by their services, added to the success of the various meetings, entertainments, etc., and takes this means of thanking the Foundry and Machine Exhibition Co., through its officers, the various hotels, particularly the Hotel Traymore, etc. It also wishes to express its appreciation of the

work of the various standing and local committees, the trade and local press and the management of Young's Million Dollar Pier.

As an association, we particularly are grateful to the authors of the various papers presented at the convention, together with those who participated in the discussions.

This resolution was adopted, with instructions to the secretary to send copies to the authors of papers presented during the convention, to hotels and others who were instrumental in making the convention a success.

The chairman then announced the appointment of a number of standing committees, but stated that he desired to take further time before completing these appointments.

The Committee on Specifications for Gray Iron Castings recommended the appointment of special committees for car wheels, pipe, agricultural and hydraulic castings.

The chairman announced that the Committee on Gray Iron Castings would remain as at present, and he would confer with the members of the Executive Committee with reference to the appointment of the sub-committees.

Benj. D. Fuller stated he understood that at the steel session Thursday afternoon, Sept. 30, motion was made that the Committee on Specifications for Steel Castings be discharged, and he moved that this action be reconsidered and that the committee be continued for another year.

This motion was discussed by Chairman R. A. Bull, as follows:

"The motion yesterday afternoon, Mr. Fuller, was not to the effect that the committee be discharged, but that the report should be laid on the table, and the gentleman who made the motion to that effect, Mr. H. E. Field, announced that in his opinion more harm than good would result from the continuance of the committee and advised that we do nothing to stir up the American Society for Testing Materials. I advised the meeting that my correspondence with the A. S. T. M. was such as to make me know that they courted co-operation and I suggested a negative vote. The meeting was poorly attended at that particular time and the motion introduced by Mr. Field to the effect that the motion be tabled, was carried. I then asked what the sense of the meeting was towards continuing the committee, suggesting that it was not necessary to continue

at all if they were not going to make some disposition of the committee's report, which had been prepared after some considerable thought, but no action was taken on that and if it is the sense of the meeting here today that this committee should be continued and that the work should go on, a motion to take up the report from the table and accept it as a preliminary report with instructions to the committee to continue its work, would be proper and regular."

Mr. Fuller then moved that the report of the committee be accepted as preliminary and that the committee be continued. This motion was seconded by Major Jos. T. Speer and was unanimously adopted.

The chairman announced that the Committee on Standard Methods for Analyzing Coke, of which H. E. Diller, of the General Electric Co., Erie, Pa., is chairman, be continued as constituted and that it work in conjunction with the committee of the American Chemical Society and the Committee on Co-Operation with the United States Bureau of Standards, of which Dr. Richard Moldenke is chairman. The other members of this committee, selected by Dr. Moldenke are W. M. Saunders, Providence, R. I., and H. E. Diller, Erie, Pa.

The chairman announced that during the past year it became necessary to make appointments to various committees which had not been authorized at the last meeting and he ventured the opinion that the same condition may arise this year. Last year he took it upon himself to make such appointments, and he asked the sense of the meeting concerning such similar action that might seem advisable this year. He stated that in any such case, he would communicate and advise with the members of the Executive Board.

Major Joseph T. Speer moved that the action of the president in appointing these committees in the past year be ratified and that he be empowered to appoint members of committees, with the approval of the Executive Board, as he deems proper. This motion was duly seconded and unanimously adopted.

The chairman then stated that it would be appropriate to advise the members concerning any invitations that had been extended for next year's meeting. He explained that no

action could be taken during this session, as the Constitution provides it shall be decided by the Executive Board.

Benj. D. Fuller, of the Westinghouse Electric & Mfg. Co., Cleveland, stated that an invitation to hold the meeting at Cleveland next year, would be extended by the Cleveland Chamber of Commerce and he personally expressed the hope that the meeting would be held in that city next year.

On behalf of Henry A. Carpenter, vice president of the A. F. A., Major Speer extended an invitation to hold the 1916 or the 1917 meeting in Boston or Providence.

The chairman announced that the registration showed a total of 513 members of the American Foundrymen's Association and 209 lady members, making a grand total A. F. A. registration of 722, establishing a new high record.

There being no further business, the meeting was declared adjourned.

Annual Banquet

Thursday, Sept. 30, 7 P. M., Hotel Traymore

Thomas Devlin, Thomas Devlin Mfg. Co., Philadelphia, was toastmaster, and the following addresses were delivered:

"Salubrities I Have Met", by John Kendrick Bangs, Ogunquit, Me.

"Foundrymen in the Making", by Dr. A. A. Hamerschlag, Carnegie Institute of Technology, Pittsburgh, Pa.

Entertainment Features

The entertainment features included an informal dance on Young's Million Dollar Pier, Monday evening, Sept. 27, a theater party, on Tuesday evening, Sept. 28, which was followed by a dance on the Garden Pier; a prize tango on Young's Million Dollar Pier, Wednesday evening, Sept. 29, and the annual banquet at the Hotel Traymore on Thursday evening, Sept. 30.

Tickets for free rides on the rolling chairs on the Board Walk were distributed to the ladies, and all members received tickets of admission to the Steel Pier.

The Registered Attendance

The following members registered their attendance at the annual meeting of the American Foundrymen's Association, held at Atlantic City, N. J., Sept. 27 to Oct. 1, 1915:

ABELL, O. J., *The Iron Age*, Chicago.
ADAMS, CHAS. E., superintendent, York Foundry & Machine Co., York, Pa.
AHARA, E. H., general superintendent, Dodge Mfg. Co., Mishawaka, Ind.
AIKEN, H. L., manager, Crucible Steel Castings Co., Cleveland.
ALDRICH, WM., salesman, Goldschmidt Thermit Co., New York.
ALKOHN, W. H., Hunt-Spiller Mfg. Corp., Boston.
ALLBRIGHT, W. A., Pangborn Corp., Hagerstown, Md.
ALTEN, GEORGE H., Alten's Foundry & Machine Works, Lancaster, O.
AMBLER, CHAS. M., assistant secretary and treasurer, Abram Cox Stove Co., Philadelphia.
AMES, WM. V., Stanley G. Flagg Co., Philadelphia.
ANDERSON, JAMES, foreman, Samuel L. Moore & Sons' Corp., Elizabethport, N. J.
ANDERSON, NILS., president, Debevoise Anderson Co., New York City.
ANGELL, WM. H., pattern shop foreman, H. B. Smith Co., Westfield, Mass.
ANDREWS, THOS. L., vice president and general manager, Bollinger-Andrews Construction Co., Pittsburgh.
ANTHES, L. L., Anthes Foundry Co., Ltd., Toronto, Ont.
APGAR, M. F., superintendent, Taylor-Wharton Iron & Steel Co., High Bridge, N. J.
ARLT, OTTO, salesman, Rogers-Brown Co., New York.
ARNOT, HAROLD V., general manager, Bonney-Floyd Co., Columbus.
ARMSTRONG, W. A., Ingersoll-Rand Co., Cleveland.
ATWATER, H. R., vice president, Osborn Mfg. Co., Cleveland.
AYERS, E. M., president, Interstate Sand Co., Zanesville, O.

BACKERT, A. O., editor, *The Foundry*, Cleveland.
BACON, CHAS. C., Ross-Tacony Crucible Co., Tacony, Philadelphia.
BAILEY, EDWIN C., Milford Iron Foundry, Milford, Mass.
BALDWIN, R. L., electric furnace representative, United States Steel Corp., New York.
BARDEN, G. A., district manager, Chicago Pneumatic Tool Co., Philadelphia.
BARNES, J. A., DR., physician, Pond Machine & Foundry Co., Worcester, Mass.
BARR, WM. H., president National Founders' Association, Buffalo.
BARRINGER, J. M., general superintendent, American Malleables Co., Lancaster, N. Y.

BASSETT, F. P., sales department, Pennsylvania Steel Co., Steelton, Pa.
BASSETT, W. H., Technical superintendent, American Brass Co., Waterbury, Conn.
BAUER, F. W., Rogers, Brown & Co., Cincinnati.
BAUMGARTNER, ARTHUR A., Thos. Devlin Mfg. Co., Philadelphia.
BEAUMONT, H. W., Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.
BENHAM, CHAS. L., demonstrator, Sand Mixing Machine Co., New York.
BENNETT, E. J., salesman, Pickands, Mather & Co., Cleveland.
BENNETT, T. BEN, manager, Maxwells, Ltd., St. Marys, Ontario, Canada.
BENNETT, WM. B., Union Steel Casting Co., Pittsburgh.
BERGER, C. L., vice president, Eastern Malleable Iron Co., Naugatuck, Conn.
BERGMAN, R., superintendent machine shop, Treadwell Engineering Co., Easton, Pa.
BERTIE, CECIL, Rogers, Brown & Co., Philadelphia.
BIETSCH, EMIL F., Wolf Co., Chambersburg, Pa.
BING, J. H., Pettinos Bros., Philadelphia.
BIRD, R. C., manager, Broadway Iron Foundry Co., Cambridge, Mass.
BLACKMAN, JOS. K., accountant, Farrell Foundry & Machine Co., Ansonia, Conn.
BLACKWOOD, A. F. S., vice president, Michigan Steel Casting Co., Detroit.
BOERS, J. A., sales agent, General Electric Co., Schenectady, N. Y.
BOWE, WM. H., Thomas Iron Co., Easton, Pa.
BOWMAN, R. K., J. L. Mott Co., Trenton, N. J.
BRADLEY, JOHN, sales representative, Sand Mixing Machine Co., New York.
BRADLEY, W. P., superintendent of foundries, American Bridge Co., Ambridge, Pa.
BRAINARD, HOWARD S., Ingersoll-Rand Co., Phillipsburg, N. J.
BRAUGHTON, A. S., superintendent, A. L. Swett Iron Works, Medina, N. Y.
BRAUCHER, PETER S., P. & R. Railway Co., Reading, Pa.
BRITT, JOS. F., McNab & Harlin Mfg. Co., Paterson, N. J.
BROUGH, E. W., foundry superintendent, Sheffield Car Co., Three Rivers, Mich.
BROWN, BANCROFT, Wm. H. Jackson Co., Brooklyn, N. Y.
BROWN, H. W., secretary, Tabor Mfg. Co., Philadelphia.
BROWN, J. F., foundry superintendent, Morgan Engineering Co., Alliance, Ohio.
BROWN, T. HAROLD, E. E. Brown & Co., Inc., Philadelphia.
BROWNE, DECOURCY, metallurgical engineer, Goldschmidt Thermit Co., New York.
BROWNE, D. J., Stanley G. Flagg & Co., Pottstown, Pa.
BRYANT, R. E., Jefferson Union Co., Lexington, Mass.
BUCH, J. E., secretary and treasurer, Buch Foundry Equipment Co., Bridgeport, Pa.
BUCH, R. S., president, Buch Foundry Equipment Co., Bridgeport, Pa.
BUCKWALTER, A. L., Buckwalter Stove Co., Royersford, Pa.
BUECHELL, L. F., foundry superintendent, American Pin Co., Waterbury, Conn.
BULL, R. A., production manager, Commonwealth Steel Co., Granite City, Ill., and president, American Foundrymen's Association.
BURKHOLDER, DANIEL E., Tabor Mfg. Co., Philadelphia.
BURMAN, GEO. A., manager oil department, E. J. Woodison Co., Detroit.

CAMP, GEO. E., secretary, Waterbury Castings Co., Waterbury, Conn.
CAREY, JAMES A., manager, Hill & Griffith Co., Pittsburgh.
CAROLIN, C. W., Enterprise Foundry Co., Detroit.
CARPENTER, HENRY A., General Fire Extinguisher Co., Providence, R. I.
CASE, CHAS. H., auditor, Abram Cox Stove Co., Philadelphia.
CHADSEY, S. B., assistant general superintendent, Massey-Harris Co., Toronto, Ont.
CHAMBERS, WM., Garden City Sand Co., Chicago.
CHAMPLIN, O. H. P., president and treasurer, Strong Steel Foundry Co., Buffalo.
CHAPMAN, R. W., T. M. Chapman's Sons' Co., Old Town, Me.
CHAPPELKA, A. H., superintendent, Chisholm & Moore Mfg. Co., Cleveland.
CHERRIE, JAMES, Fairbanks Valve Co., Binghampton, N. Y.
CHRISTIAN, F. G., president, Acme Foundry Co., Detroit.
CLARE, P. C., foreman, Pennsylvania Railroad Co., Altoona, Pa.
CLARK, R. W., Rogers, Brown & Co., New York.
COADY, THOS. F., superintendent, Kennedy Foundry Co., Baltimore.
COLE, FRED .V., circulation manager, Penton Publishing Co., Cleveland.
COLTMAN, JAS. D., superintendent, Waterbury Casting Co., Waterbury, Conn.
COLEMAN, JAS. H., salesman, Tabor Mfg. Co., Cleveland.
COSTLEY, S. R., J. S. McCormick Co., Pittsburgh.
CREIGHTON, A. B., foundry foreman, Carolina Machinery Co., Ashville, N. C.
CUSHING, GEO. H., general superintendent, H. B. Smith Co., Westfield, Mass.

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DAVIES, GEO. C., manager foundry department, Pilling & Crane, Philadelphia.
DEDE, JOHN H., salesman, Stanley Doggett, New York.
DEININGER, S. W., Madco Foundry & Machine Co., Phoenixville, Pa.
DERBY, H., foundry foreman, Lansdowne Crucible Steel Co., Detroit.
DEVLIN, C. J., Thos. Devlin Mfg. Co., Philadelphia.
DEITZ, CARL F., assistant sales manager, Norton Co., Worcester, Mass.
DILLER, H. E., General Electric Co., Erie, Pa.
DISS, DANIEL B., Universal Caster & Foundry Co., Newark, N. J.
DITHRIDGE, EDW., J. L. Mott Co., Trenton, N. J.
DODGE, F. H., salesman, S. Obermayer Co., Cleveland.
DOGGETT, STANLEY, Stanley Doggett, New York.
DOLAN, M., general foreman, Louisville & Nashville Railroad, Louisville.
DOOLITTLE, E. L., superintendent, Eastern Malleable Iron Co., Bridgeport, Conn.
DOPP, J. W., International Molding Machine Co., Chicago.
DORSEY, W. A., Bonney-Floyd Co., Columbus.
DOTTERRER, A. W., Buckwalter Stove Co., Royersford, Pa.
DOUGHERTY, WM. J., Ajax Metal Co., Philadelphia.
DROLET, EMILE, F. H. Drolet Co., Quebec, Canada.
DROUGHT, J. G., sales manager, U. S. Graphite Co., Chicago.
DRYSDALE, ALEX T., U. S. Cast Iron Pipe & Foundry Co., Burlington, N. J.
DUMBERK, J. R., superintendent, T. H. Symington Co., Rochester, N. Y.
DYER, Y. A., assistant sales manager, Alabama Co., Birmingham.

ENGLAND, GEORGE, Edgar Thompson Works, Braddock, Pa .
EPPELE, FRANK J., general manager, Trenton Malleable Iron Co., Trenton, N. J.
ESTEP, H. COLE, associate editor, *The Foundry*, Cleveland.
EVANS, DAVID, president, Chicago Steel Foundry Co., Chicago.
EVANS, HOWARD, vice president, J. W. Paxson Co., Philadelphia.

FACKLER, J. M., foundry foreman, Domestic Engine & Pump Co., Shippensburg, Pa.
FARRELL, E. H., general manager, Philip Smith Mfg. Co., Sidney, Ohio.
FASSBINDER, HENRY G., chemist, Minneapolis Steel & Machinery Co., Minneapolis.
FIELD, H. E., president, Wheeling Mold & Foundry Co., Wheeling, W. Va.
FISCHER, ANTHONY, foreman, United Engineering & Foundry Co., Pittsburgh.
FISCHER, GEO. J., secretary and manager, Modern Iron Works, Quincy, Ill.
FISHER, HENRY F., foundry foreman, A. B. Farquhar Co., New York.
FITZPATRICK, W. H., S. Obermayer Co., Pittsburgh.
FITZPATRICK, W. M., S. Obermayer Co., Pittsburgh.
FITTS, F. E., Rogers, Brown & Co., Boston.
FLAGG, STANLEY G., 3rd, Stanley G. Flagg & Co., Philadelphia.
FLEMING, J. R., president, J. R. Fleming & Son, Scranton, Pa.
FORGENT, GEO. C., manager, Blake & Knowles Steam Pump Co., East Cambridge, Mass.
FOX, JAMES, Union Switch & Signal Co., Pittsburgh.
FRANK, M. K., Damascus Bronze Co., Pittsburgh.
FRANTZ, J. N., Universal Caster & Foundry Co., Newark, N. J.
FRASER, W. D., foundry superintendent, Power Specialty Co., Dansville, N. Y.
FRISKEY, CHAS. D., International Molding Machine Co., Chicago.
FROHMAN, E. D., vice president, S. Obermayer Co., Pittsburgh.
FROST, E. THEODORE, president, Smiths Falls Malleable Castings Co., Smith Falls, Ont.
FRYE, WM. C., treasurer, Chain Belt Co., Milwaukee.
FULLER, BENJ. D., superintendent of foundries, Westinghouse Electric & Mfg. Co., Cleveland.
FULTON, A. M., assistant superintendent, Ft. Pitt Malleable Iron Co., Pittsburgh.
FUNK, P. S., assistant foreman, Oscar Barnett Foundry Co., Newark, N. J.

GALLAGHER, HUGH, salesman, Davenport Machine & Foundry Co., Davenport, Ia.
GALLIGAN, J. A., sales agent, Pickands, Brown & Co., Chicago.
GALVIN, J. E., Ohio Steel Foundry Co., Lima, O.
GARRETT, J. F., manager, Hennessy Foundry Co., Springfield, O.

GIBBY, ARTHUR W., president, Gibby Foundry Co., East Boston, Mass.
GIBNEY, JAS. W., works manager, W. P. Taylor Co., Buffalo.
GIBSON, C. B., Westinghouse Electric & Mfg. Co., Baltimore.
GILMORE, L. E., Baltimore Malleable & Steel Co., Baltimore.
GLASS, J. M., Hill & Griffiths Co., Cincinnati.
GLASSCOT, THOS., salesman, Pickands, Brown & Co., Chicago.
GODARD, FRANK B., sales manager, U. S. Graphite Co., Pittsburgh.
GOLDMAN, C. M., salesman, S. Obermayer Co., Philadelphia.
GOOD, THOS. R., foundry foreman, E. & T. Fairbanks & Co., St. Johnsbury, Vt.
GORDON, F. E., president, Gordon Sand Co., Conneaut, O.
GOSCHENHOFER, JOHN, Enterprise Foundry Co., Detroit.
GRAY, B. L., instructor, Washburn Shops, Worcester, Mass.
GRIPPIN, W. J., treasurer, Eastern Malleable Iron Co., Bridgeport, Conn.
GREUSS, WM. J., Pickands, Mather & Co., Cleveland.
GUNN, J. M., foundry manager, McClary Mfg. Co., London, Ont.

HALEY, H. H., salesman, Sand Mixing Machine Co., New York.
HALTEMAN, JOHN K., foreman, Abram Cox Stove Co., Philadelphia.
HAMEL, F. W., salesman, International Molding Machine Co., Chicago.
HARDER, GEORGE A., Essex Foundry, Newark, N. J.
HARRINGTON, R. F., chemist, Hunt-Spiller Mfg. Corp., Boston.
HARRIS, M. G. L., purchasing agent, Wm. M. Crane Co., New York.
HASKINS, E. O., Richmond Radiator Co., New York.
HATHAWAY, H. K., vice president, Tabor Mfg. Co., Philadelphia.
HAYES, R. W. E., manager, Hayes Pump & Planter Co., Galva, Ill.
HAYS, G. O., *The Iron Trade Review*, New York.
HEARTT, WM. A., Sand Mixing Machine Co., New York.
HENRY, J. B., general superintendent, Union Steel Castings Co., Pittsburgh.
HERSHER, W. T., foundry foreman, Eastern Malleable Iron Co., Bridgeport, Conn.
HESKERT, J. A., Pangborn Corp., Hagerstown, Md.
HIBBS, J. S., assistant general manager, J. W. Paxson Co., Philadelphia.
HILL, JOHN, manager, Hill-Brunner Foundry Supply Co., Cincinnati.
HILLIARD, HENRY F., Essex Foundry, Newark, N. J.
HOFFMAN, W. L., manager, Hickman, Williams & Co., Philadelphia.
HOLMES, A., Tabor Mfg. Co., Philadelphia.
HOLMGREEN, J. H., president, Aloma Iron Works, San Antonio, Texas.
HORTON, MORGAN, foreman, Baltimore Malleable Iron & Steel Casting Co., Baltimore.
HOWELL, A. E., superintendent, Phillips & Buttorff Mfg. Co., Nashville, Tenn.
HOWES, G. W., superintendent, Estate of P. D. Beckwith, Dowagiac, Mich.
HOWLAND, A. W., eastern representative, *The Foundry*, New York.
HOYT, C. E., secretary, Foundry & Machine Exhibition Co., Chicago.
HUBBARD, STERLING, Rogers, Brown & Co., Cleveland.

IMPEY, H. W., salesman, Tabor Mfg. Co., Philadelphia.

JAMESON, A. H., manager steel department, Malleable Iron Fittings Co., Brantford, Conn.
JANSSEN, W. A., superintendent, Bettendorf Co., Bettendorf, Ia.
JENSEN, ARTHUR F., Mumford Molding Machine Co., Chicago.
JEWELL, W. E., president, Jewell Steel & Malleable Co., Buffalo.
JOHNSON, NATHANIEL, engineer, Tabor Mfg. Co., Philadelphia.
JOHNSTON, S. T., sales manager, S. Obermayer Co., Chicago.
JONES, G. E., metallurgist, Whiting Foundry Equipment Co., Harvey, Ill.
JONES, I. L., treasurer, International Heater Co., Utica, N. Y.
JONES, JAMES, pattern foreman, Pittsburgh Valve Foundry & Construction Co., Pittsburgh.
JUSTICE, DAVID G. P., superintendent, Pittsburgh Valve Foundry & Construction Co., Pittsburgh.

KARR, C. P., associate physicist, Bureau of Standards, Washington, D. C.
KELLER, H. D., superintendent, Ideal Furnace Co., Detroit.
KELLEY, A. N., superintendent, Modern Foundry Co., Cincinnati.
KELLEY, H. D., Goldschmidt Thermit Co., New York.
KENDRICH, ALLIE, foreman, Lombard Iron Works & Supply Co., Augusta, Ga.
KENNEDY, P. J., superintendent, Baltimore Malleable Iron & Steel Casting Co., Baltimore.
KENNEDY, R. E., instructor of foundry work, University of Illinois, Urbana, Ill.
KENNEDY, THOS. A., foundry superintendent, Oscar Barnett Foundry Co., Irvington, N. Y.
KIBBE, L. G., president, Turner & Seymour Mfg. Co., Torrington, Conn.
KING, H. E., foundry superintendent, Washington Steel & Ordnance Co., Washington, D. C.
KIRKLAND, A. J., Keystone Stove Foundry, Spring City, Pa.
KIRSCH, W. R., foundry superintendent, Schaum & Uhlinger, Inc., Philadelphia.
KLOCHARS, CHAS. O., Essex Foundry Co., Newark, N. J.
KNOTT, WM., superintendent, Eastern Malleable Iron Co., Troy, N. Y.
KNOTTS, G. M., manager, United Engineering & Foundry Co., Pittsburgh.
KNOWLTON, C. F., Westinghouse Electric & Mfg. Co., Pittsburgh.
KNOX, H. G., Navy Yard, Norfolk, Va.
KOCH, C. S., Fort Pitt Steel Casting Co., McKeesport, Pa.
KOCH, GEO. B., general foreman, Pennsylvania Railroad, Altoona, Pa.
KOCH, H. J., secretary, Fort Pitt Steel Casting Co., McKeesport, Pa.
KREMER, I. F., J. W. Paxson Co., Philadelphia.
KREUTZBERG, E. C., New York representative, Penton Publishing Co., New York.
KULP, W. WILSON, Keystone Stove Foundry, Spring City, Pa.

LAMARCHE, CARL F., president, American Malleable Casting Co., Marion, O.
LAMARCHE, CHAS. L., treasurer, American Malleable Casting Co., Marion, O.

LAMPKIN, W. W., sales manager, United States Graphite Co., Philadelphia.
LANAHAN, J. S., vice president, Ft. Pitt Malleable Iron Co., Pittsburgh.
LANE, H. M., president, H. M. Lane Co., Detroit.
LANSDOWNE, D. P., secretary, West Steel Casting Co., Cleveland.
LAUCKS, JOHN H., foundry foreman, S. J. Cresswell Iron Works, Philadelphia.
LEE, JAMES T., Mumford Molding Machine Co., Chicago.
LEE, WALTER T., U. S. Cast Iron Pipe & Foundry Co., Chestnut Hill, Philadelphia.
LEHMAN, WM., foundry superintendent, Metric Metal Works, Erie, Pa.
LENT, THOS. K., foundry superintendent, Wm. M. Crane Co., Jersey City, N. J.
LESH, IRA B., manager, Railway Materials Co., Chicago.
LESPERANCE, L. T., foundry superintendent, Turner & Seymour Mfg. Co., Torrington, Conn.
LEWIS, WILFRED, president, Tabor Mfg. Co., Philadelphia.
LINDSAY, A. H., JR., Hunt-Spiller Mfg. Corp., Boston.
LITTLE, JOHN W., foundry superintendent, Landis Tool Co., Waynesboro, Pa.
LOGAN, DAVID, demonstrator, Sand Mixing Machine Co., New York.
LOMBARD, GEORGE S., vice president, Lombard Iron Works & Supply Co., Augusta, Ga.
LOMBARD, GEORGE R., Lombard Iron Works & Supply Co., Augusta, Ga.
LONG, GEORGE, A. T., Pickands, Brown & Co., Chicago.
LONG, J. W., general manager, Mahoning Foundry Co., Youngstown, O.
LOVELL, C. S., foundry superintendent, Walker & Pratt Mfg. Co., Boston.
LYND, ROY E., assistant superintendent, Richardson & Boynton Co., Dover, N. J.
LYND, W. T. R., Richardson & Boynton Co., Dover, N. J.
LYTLE, WM. C., Pangborn Corp., Hagerstown, Md.

MCCARTHY, F., salesman, Hill & Griffith Co., Cincinnati.
MCCARTHY, JOHN, superintendent, Broadway Iron Foundry Co., Cambridge, Mass.
MCCORMICK, J. S., president, J. S. McCormick Co., Pittsburgh.
MCDEVITT, J. J., salesman, S. Obermayer Co., Chicago.
MACDONALD, A. E., purchasing agent, Crane Co., Bridgeport, Conn.
MACDONALD, H. P., superintendent, Snead & Co. Iron Works, Jersey City, N. J.
MACDONALD, ROBT., foundry manager, Saml. L. Moore & Sons' Corp., Elizabeth, N. J.
MACDONALD, W. T., buyer, Schaum & Uhlinger, Inc., Philadelphia.
MCEWEN, J. H., president, McEwen Mfg. Co., Tulsa, Okla.
MCGLYNN, J. B., superintendent, West Steel Castings Co., Cleveland.
MCKAIG, W. W., McKaig Machine, Foundry & Supply Works, Cumberland, Md.
MCKEWEN, EDW., Baltimore Malleable Iron & Steel Casting Co., Baltimore.
MCLADDEN, M. L., Enterprise Co., Columbiana, O.

McLAIN, DAVID, president and manager, McLain's System, Milwaukee.
McLAIN, R. H., engineer, General Electric Co., Schenectady, N. Y.
McNAMARA, J. J., foreman, Hunt-Spiller Mfg. Corp., Boston.
McNAMARA, P. J., proprietor, McNamara, Koster Foundry Co., Indianapolis.
MA GIRL, P. H., Bloomington, Ill.
MALONE, T. E., secretary, J. S. McCormick Co., Pittsburgh.
MAMPLE, WM. R., superintendent, Aluminum Casting Co., Fairfield, Conn.
MANNWEILER, E., secretary, Eastern Malleable Iron Co., Naugatuck, Conn.
MARTIN, GEO. H., Davis Foundry, Inc., Hornell, N. Y.
MARTIN, S. A., foreman, Pennsylvania Railroad Co., Altoona, Pa.
MATHEWS, C. D., R. D. Wood & Co., Camden, N. J.
MATTHEWS, F. L., president and treasurer, Weller Hardware & Foundry Co., Horseheads, N. Y.
MATTERN, F. C., director of factories, Fairbanks Co., Binghampton, N. Y.
MEACHAM, STANDISH, Rogers, Brown & Co., Cincinnati.
MENZE, A. E., superintendent, Steinway & Sons, Long Island City, N. Y.
MERCER, JOHN T., superintendent, American Engineering Co., Philadelphia.
MESSINGER, C. R., vice president, Sivyer Steel Casting Co., Milwaukee.
MEYER, A. J., general superintendent, Abram Cox Stove Co., Philadelphia.
MILLER, A. J., treasurer, Whitehead Bros. Co., Providence, R. I.
MILLER, C. J., manager, Medina Foundry Co., Medina, O.
MILLER, W. H., foundry superintendent, Deere & Mansur Co., Moline, Ill.
MILLER, W. W., vice president, International Molding Machine Co., Chicago.
MILLS, G. P., sales agent, General Electric Co., Schenectady, N. Y.
MILNOR, THOS. W., president, Kline Hardware Co., Allentown, Pa.
MINICH, V. E., vice president and general manager, Sand Mixing Co., New York.
MOLDENKE, RICHARD, consulting metallurgist, Watchung, N. J.
MORGAN, CHAS., vice president and superintendent, Arcade Mfg. Co., Freeport, Ill.
MORGAN, E. H., president and treasurer, Arcade Mfg. Co., Freeport, Ill.
MORGAN, J. E., Hickman, Williams & Co., Philadelphia.
MOORE, E. A., E. A. Moore Foundry, Reading, Pa.
MOORE, F. H., Richmond Radiator Co., New York.
MOORE, GEO. N., foundry manager, Robeson Process Co., New York.
MOORE, J. M. C., buyer, McClary Mfg. Co., London, Ont.
MOORE, J. TURNER, Reading Steel Casting Co., Reading, Pa.
MORROW, E. J., general manager, Electric City Foundry Co., Schenectady, N. Y.
MOTT, ABRAM C., vice president, Abram Cox Stove Co., Philadelphia.
MOTT, ABRAM C., JR., Abram Cox Stove Co., Philadelphia.
MOYER, ALBERT W., New York City.
MUIR, CHAS. S., foundry manager, Schaum & Uhlinger, Inc., Philadelphia.
MULVEY, JAS. C., foundry superintendent, Rensselar Valve Co., Troy, N. Y.
MULVEY, WM. G., Rensselar Valve Co., Troy, N. Y.
MUNNOCH, P., chemist, American Brake Shoe & Foundry Co., Mahwa, N. J.

MUNTZ, G., vice president, Tropenas Converter Co., New York.
MURPHY, MARTIN F., American Locomotive Co., Schenectady, N. Y.
MURRAY, JAMES, Gardner General Foundry Co., Gardner, Mass.
MURRAY, JOHN H., president, Trenton Malleable Iron Co., Trenton, N. J.
MUSE, RICHARD, superintendent, Marshall Foundry Co., Pittsburgh.

NEALE, ALFRED, foreman, Stanley Works, Bridgewater, Mass.
NEILSON, EMIL, S. L. Moore & Sons' Corp., Elizabeth, N. J.
NEWCOMB, F. F., New England representatives, Pilling & Crane, Philadelphia.
NORDFELDT, CHAS., pattern foreman, Fort Pitt Steel Casting Co., McKeesport, Pa.
NORDHOLT, J. B., vice president, Toledo Steel Casting Co., Toledo, O.
NORTON, R. H., Penn Steel Casting & Machine Co., Chester, Pa.

O'BRIEN, THOS. J., purchasing agent, Fort Pitt Malleable Iron Co., Pittsburgh.
O'CONNOR, A. J., superintendent, Hunt-Spiller Mfg. Co., Boston.
O'LEARY, THOS., president, Pond Machine & Foundry Co., Worcester, Mass.
O'NEIL, J. P., Western Foundry Co., Chicago.
OBERHELMAN, J. A., proprietor, J. A. Oberhelman Foundry Co., Cincinnati.
OBERHELMAN, WM., vice president, Hill & Griffith Co., Birmingham, Ala.
OLIVER, W. H., Hickman, Williams & Co., Cincinnati.
ORBISON, J. B., superintendent, International Heater Co., Utica, N. Y.
ORMROD, JOHN D., Donaldson Iron Co., Emaus, Pa.
OSTERHOLN, CHAS., Edgar Thompson Foundries, Braddock, Pa.

PAIGE, J. B., factory superintendent, E. & T. Fairbanks Co., St. Johnsbury, Vt.
PALMER, A. R., purchasing agent, Thomas Iron Co., Easton, Pa.
PANGBORN, JOHN C., vice president, Pangborn Corp., Hagerstown, Md.
PANGBORN, THOS. W., president, Pangborn Corp., Hagerstown, Md.
PARTRIDGE, W. E. B., foundry superintendent, Union Tool Co., Los Angeles, Cal.
PATTON, ROBT. A., president, Abram Cox Co., Philadelphia.
PEASE, J. D., advertising manager, Penton Publishing Co., Cleveland.
PELOTT, L. C., western representative, *The Iron Trade Review*, Chicago.
PERKINS, F. N., president, Foundry & Machine Exhibition Co., Freeport, Ill.
PERO, J. P., general superintendent, Missouri Malleable Iron Co., East St. Louis, Ill.

PETERSON, P. C., superintendent, W. A. Jones Foundry & Machine Co., Chicago.
PETTINGILL, GEO. B., purchasing agent, T. H. Symington Co., Rochester, N. Y.
PHILLIPS, W. J., president, Phillips & McLaren Co., Pittsburgh.
PIKE, E. W., Detroit Steel Castings Co., Detroit.
POMEROY, W. D., vice president, Goulds Mfg. Co., Seneca Falls, N. Y.
PORTER, A. C., foundry superintendent, Lufkin Foundry & Machine Co., Lufkin, Texas.
PORTER, J. W., general sales manager, Alabama Co., Birmingham, Ala.
POTTER, P. J., Pangborn Corp., Hagerstown, Md.
POTTS, J. G., foundry superintendent, Taylor-Wharton Iron & Steel Co., High Bridge, N. J.
PRIDMORE, EDWARD A., International Molding Machine Co., Chicago.
PRIDMORE, HARRY A., Henry E. Pridmore, Chicago.
PRINCE, W. F., foundry engineer, New York City.
PUTNAM, W. D., president, Detroit Testing Laboratories, Detroit.

QUINN, T. S., treasurer, Lebanon Steel Foundry, Lebanon, Pa.

RAHL, JOHN C., United Engineering & Foundry Co., Pittsburgh.
RATHBONE, JOHN A., Empire Foundry Co., New Brunswick, N. J.
RAYNER, GEO. R., secretary, Carborundum Co., Niagara Falls, N. Y.
READ, H., Read Machinery Co., York, Pa.
READ, O. R., Read Machinery Co., York, Pa.
REBMANN, HARRY F., American Engineering Co., Philadelphia.
REICHERT, GEO. J., assistant superintendent, T. H. Symington Co., Rochester, N. Y.
REMLY, CHAS. J., foundry superintendent, Russell & Co., Massillon, O.
RENNEBERG, CHAS., foundry superintendent, McNab & Harlin Mfg. Co., Paterson, N. J.
RHOADS, H. F., foreman, Empire Foundry Co., New Brunswick, N. J.
RICKER, A. J., president, Badger Malleable & Mfg. Co., South Milwaukee, Wis.
RILEY, FRANK, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.
ROBERTS, HENRY, Harry E. Campbell, Albany, N. Y.
ROBESON, D. S., Philadelphia, Pa.
ROFFMAN, HENRY A., manager, Stanley Doggett, New York.
ROMINGER, GEO. S., Girard Iron Works, Philadelphia.
ROOT, A. B., JR., Hunt-Spiller Mfg. Corp., Boston
ROSENBERGER, W. A., Pangborn Corp., Hagertown, Md.
ROUSE, E. B., sales agent, Morgan Engineering Co., Alliance, O.
RUNNER, MARTIN, foreman, Schaum & Uhlinger, Inc., Philadelphia.
RYAN, T. J., Robeson Process Co., New York.

SARGENT, W. D., president, Bayonne Steel Casting Co., Bayonne, N. J.
SAUNDERS, WALTER M., chemist, Saunders & Franklin, Providence, R. I.

SAVOURNIN, W. J., salesman, Pilling & Crane, Philadelphia.
SCHERRER, JOHN C., Empire Foundry Co., New Brunswick, N. J.
SCHILLING, P. J., sales manager, Eastern Malleable Iron Co., Troy, N. Y.
SCHNEIDER, GEO. B., Fillmore Ave. Foundry & Engine Works, Buffalo.
SCOTT, DAVID, Carnegie Steel Co., Braddock, Pa.
SCHRUFER, CHAS. F., sales agent, Baltimore Malleable Iron & Steel Casting Co., Baltimore.
SCHWAB, E. J., S. Birkenstein & Sons, Chicago.
SEAMAN, J. S., Seaman-Sleeth Co., Pittsburgh.
SHAFFEE, W. W., foundry foreman, Hermance Machine Co., Williamsport, Pa.
SHAW, B. M., superintendent, Walker & Pratt Mfg. Co., Watertown, Mass.
SHECK, FRANK, foreman, Baltimore Malleable Iron & Steel Casting Co., Baltimore.
SHECKLER, M. O., Union Switch & Signal Co., Swissvale, Pa.
SHERWIN, JOHN, president, Chicago Hardware Foundry Co., North Chicago, Ill.
SHUGG, L. W., advertising department, General Electric Co., Schenectady, N. Y.
SHUMANN, A. A., foundry superintendent, J. L. Mott Co., Trenton, N. J.
SIMPSON, P. L., manager, National Engineering Co., Chicago.
SLEETH, S. D., superintendent, Westinghouse Air Brake Co., Pittsburgh.
SLEICHER, RALPH H., vice president, West Side Foundry Co., Troy, N. Y.
SMITH, CHAS. G., Abrasive Materials Co., Philadelphia.
SMITH, F. E., foundry superintendent, Smith & Anthony Co., Walsefield, Mass.
SMITH, I. R., secretary, Sterling Wheelbarrow Co., Milwaukee.
SMITH, JAS., Piedmont Foundry & Machine Co., Piedmont, W. Va.
SMITH, J. C., vice president, McNab & Harlin Mfg. Co., Paterson, N. J.
SMITH, ROBT., president, Piedmont Foundry & Machine Co., Piedmont, W. Va.
SMITH, ROBT., JR., foreman, Piedmont Foundry & Machine Co., Piedmont, W. Va.
SMITH, WM. F., McNab & Harlin Mfg. Co., Paterson N. J.
SNOWDEN, SAMUEL, Foundry Manganese Co., Philadelphia.
SOULTS, THOS. A., general superintendent, Sill Stove Works, Rochester, N. Y.
SPEER, JOS. T., president, Pittsburgh Valve Foundry & Construction Co., Pittsburgh.
SPENCER, B. M., foreman, Bradley & Hubbard Mfg. Co., Meriden, Conn.
SPILSBURY, H. G., metallurgist, Goldschmidt Thermit Co., Chicago.
STACY, H. E., Niles-Bement-Pond Co., Plainfield, N. J.
STAPLES, F. M., manager, McFarland Foundry & Machine Co., Trenton, N. J.
STAPLETON, FRANCIS P., Thos. Devlin Mfg. Co., Philadelphia.
STENGEL, A. F., Rogers, Brown & Co., Buffalo.
STEBBINS, CHAS. H., Jefferson Union Co., Lexington, Mass.
STEVENSON, C. G., president and manager, Stevenson Co., Wellsville, O.
STOUGHTON, BRADLEY, secretary, American Institute of Mining Engineers, New York.
STOCKHAM, H. C., Stockham Pipe & Fittings Co., Birmingham, Ala.
STONE, FLOYD, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.
STONEHAM, S., superintendent, Michigan Steel Castings Co., Detroit.
STOOPS, R. J., vice president and manager, Treadwell Engineering Co., Easton, Pa.

STRAUB, J. W., assistant to president, Morton D. Smith Co., New York.
STUMP, W. G. H., Pangborn Corp., Hagerstown, Md.
SULLIVAN, GEORGE M., Rogers, Brown & Co., Philadelphia.
SUTHERLAND, W. S., foundry superintendent, Lord & Burnham Co., Irvington on the Hudson, N. Y.
SUTTON, ROBT. S., Indiana Foundry Co., Indiana, Pa.
SWAN, H. B., assistant superintendent of foundries, Cadillac Motor Car Co., Detroit.
SWEETSER, R. H., president, Thomas Iron Co., Easton, Pa.
SWIFT, W. F., secretray and treasurer, City Foundry Co., Cleveland.
SYMINGTON, DONALD, general manager, T. H. Symington Co. Rochester, N. Y.

TAGGART, E. M., J. W. Paxson Co., New York.
TALBOT, CLIFFORD, Alberger Pump & Condenser Co., Newburgh, N. J.
TAYLOR, J. A., Bridgeport, Conn.
TAYLOR, W. E., treasurer, Taylor & Co., Brooklyn.
TAYLOR, W. H., Ross-Tacony Crucible Co., Philadelphia.
THOMAS, R. N., Eastern Malleable Iron Co., Naugatuck, Conn.
THOMPSON, H. L., Davenport & Keeler, Inc., New Britain, Conn.
THOMPSON, W. R., W. R. Thompson & Co., Detroit.
THUM, RICHARD T., Girard Iron Works, Philadelphia.
TIERNEY, E. F., Springfield Facing Co., Springfield, Mass.
TIERNEY, JAMES, foundry superintendent, H. B. Smith Co., Westfield, Mass.
TOLMIE, ROBT. C., general manager, Lobdell Car Wheel Co., Wilmington, Del.
TOMLINSON, T., T. Tomlinson & Son, Toronto, Ont.
TREMELLEN, W. E., foundry foreman, Lewis Foundry & Machine Co., Pittsburgh.
TROUTMAN, W. E., United Engineering & Foundry Co., Vandergrift, Pa.
TUTEIN, D. A., Thomas Iron Co., Easton, Pa.
TUTEIN, E. A., Thomas Iron Co., Easton, Pa.

UHLER, J. LLOYD, metallurgist, Union Steel Casting Co., Pittsburgh.
UMSTEAD, EARL, Stanley G. Flagg & Co., Pottstown, Pa.
UTLEY, S. W., Detroit Steel Casting Co., Detroit.

VANDERVORT, F. F., Wheeling Mold & Foundry Co., Philadelphia.
VAN O'LINDA, F., field sales manager, Consolidation Coal Co., Chicago.
VAN ORMAN, T. R., vice president and manager, Empire Foundry Co., Syracuse, N. Y.

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VAN ZANDT, W. J., superintendent, Straight Line Engine Co., Syracuse, N. Y.
VIAL, F. K., Griffin Wheel Co., Chicago.
VOSKI, JAMES, Somerville Iron Works, Somerville, N. J.

WADSWORTH, H. L., American Foundry Equipment Co., Cleveland.
WALDO, F. J., Rogers, Brown & Co., Buffalo.
WALKER, A. W., president, Walker & Pratt Mfg. Co., Boston.
WALKER, ELBRIDGE, general sales agent, Thomas Iron Co., Easton, Pa.
WALKER, J. E., general manager, Eastern Malleable Iron Co., Wilmington, Del.
WALKER, RICHARD D., Walker & Pratt Mfg. Co., Boston.
WALTON, GEO., secretary, Madison Foundry Co., Cleveland.
WARNER, OSCAR L., superintendent, Eastern Malleable Iron Co., Naugatuck, Conn.
WARREN, A. G., general superintendent, J. W. Paxson Co., Philadelphia.
WATLEY, GEORGE O., Tabor Mfg. Co., Philadelphia.
WAY, L. A., superintendent, Duquesne Steel Foundry Co., Pittsburgh.
WEBSTER, G. C., secretary, Geneva Metal Wheel Co., Geneva, O.
WECHT, M. M., Sand Mixing Machine Co., New York.
WEILER, RUDOLPH B., Sharples Separator Co., West Chester, Pa.
WEINGARTEN, EDW., *The Iron Age*, New York.
WELKER, M. G., chemist, Pennsylvania Railroad Co., Altoona, Pa.
WELSH, E. C., N. & W. Railroad, Roanoke, Va.
WETZLER, J. D., purchasing agent, Chester Steel Castings Co., Philadelphia.
WENDT, HENRY W., JR., foundry manager, Buffalo Forge Co., Buffalo.
WERNER, FRANK J., Abram Cox Stove Co., Philadelphia.
WEST, RALPH H., president, West Steel Casting Co., Cleveland.
WERT, C. A., salesman, Tabor Mfg. Co., Philadelphia.
WHEELER, RUSSEL, purchasing agent, International Heater Co., Utica, N. Y.
WHITE, JOHN R., J. S. White Co., Pawtucket, R. I.
WHITE, W. B., Stanley G. Flagg & Co., Philadelphia.
WHITEHEAD, J. H., Whitehead Bros. Co., New York.
WHITEHEAD, V. L., JR., manager, Whitehead Bros. Co., Buffalo.
WHITLOCK, F. B., treasurer and manager, Interstate Foundry Co., Cleveland.
WHITMARSH, E. B., Pittsburgh Valve Foundry & Construction Co., Pittsburgh.
WILLIAMSON, C. N., U. S. Graphite Co., Saginaw, Mich.
WILLIAMSON, H., pattern foreman, Hunt-Spiller Mfg. Corp., Boston.
WILSON, CHAS. B., Wilson Foundry & Machine Co., Pontiac, Mich.
WILSON, D. C., Newark, N. J.
WILSON, J. J., foundry superintendent, General Motors Co., Detroit.
WILSON, T. A., Rogers, Brown & Co., Pittsburgh
WILTSHIRE, C. L., foundry superintendent, General Electric Co., Schenectady, N. Y.
WINSLOW, GEO. F., foundry foreman, Bradley & Hubbard Mfg. Co., Meriden, Conn.
WINTER, ANTHONY, foundry superintendent, Straight Line Engine Co., Syracuse, N. Y.

WOOD, WALTER, R. D. Wood & Co., Philadelphia.
WOODFORD, A. F., secretary, Sessions Foundry Co., Bristol, Conn.
WRIGHT, P. E., sales agent, Thomas Iron Co., Philadelphia.
WRIGHT, WILLARD M., sales agent, Thomas Iron Co., Easton, Pa.

ZIETZ, W. B., Tabor Mfg. Co., Philadelphia.
ZIPP, JOHN, superintendent, Cahill Iron Works, Chattanooga, Tenn.
ZUCK, E. S., Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

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Annual Address

By the President, R. A. BULL

One of the duties annually devolving upon your principal executive officer is that of submitting in a formal way, appropriate comments relating to our past and prospective activities. It is an honor which I highly appreciate to have served for this year as your president, and, now near the close of my official term, to be afforded this opportunity of addressing myself in a personal way to the men who by their confidence, friendship and inspiration have endeared themselves to me in no small degree, and who by their keen and enduring interest in your association have made of it an organization which today commands the esteem of technical and scientific bodies of the highest rank. For years the American Foundrymen's Association has been the acknowledged leader among technical foundry organizations of the world. Our proceedings are now given much space in European journals devoted to the manufacture of iron and steel. It would be superfluous for me to elaborate upon our standing as an educational body among foundries on the American continent. The prestige which we today happily enjoy is due in large measure to the unremitting, effective and altruistic energies of that splendid group of men who in the 20 years of our growth have constituted our executive boards, and who, led by the distinguished gentlemen who have preceded me as president, have capably supported these executives in the wise policies which now bear fruit in such abundant fashion.

Acknowledgments

You may feel that this is no time for perfunctory panegyrics. I shall inflict none upon you. But I would be unworthy of the support which I have received so freely, should I fail to make some appropriate acknowledgements.

To our able secretary-treasurer, A. O. Backert, I feel very deeply indebted. I know that he has given much of his time to the duties of his office at serious inconvenience to himself. His marked ability as a secretarial officer and his broad knowledge of the foundry business, make him one of our very valuable assets. His supreme fairness to all and his never-failing geniality have made my official relationship with him a very happy one, which I trust many of my successors will enjoy.

To each of our past presidents and vice presidents who have served on the executive board with me, I am under many obligations. They have responded to my requests for advice in a most helpful manner, and have shown clearly their great fitness for the task of guiding our destinies. In this connection, I cannot refrain from commenting upon the wisdom of your providing by the terms of the constitution that the past presidents shall serve on the executive board for life. I congratulate you upon this clause, because I know how our past presidents maintain their active interest. The sagacity, inspiration and prestige which we secure through the continued active participation in our affairs of such noble patriarchs as "Daddy" Seaman and Major Speer are of inestimable worth to us. Naturally I have sought advice more often from my immediate predecessor, Alfred E. Howell, than from those who went before him, because I knew him by the nature of things to be most closely in touch with our current affairs. He has been a never-failing source of wisdom for me, and his consideration, his clearness of vision, and his deeply rooted common sense, as exemplified so often when I had the honor of serving him as senior vice president, have made me appreciate my own deficiencies.

To our committees, and especially to their capable chairmen, I feel particularly grateful. They have been painstaking in their efforts to solve the questions entrusted to them. Their reports and recommendations speak more eloquently in their behalf than can I in this brief but sincere tribute to their efficiency. The committee which naturally became heir to the greatest task is that on papers, which has been admirably headed for the second consecutive year by Harry B. Swan.

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I need only direct your notice to the character of our sessions as evidence of the splendid work that has been done by this committee, whose success has not been achieved without the expenditure of much well-directed effort, particularly on the part of its chairman, in praise of whom I am very earnest.

To one and all who have helped me in my term as president, I am profoundly thankful. The pleasure of official service which has been mine has been increased immeasureably by the joy that springs from appreciation of the indispensable and freely given assistance of good friends. In this, as in placing me at the head of your splendid organization, you have honored me much beyond my merits. I am incapable of expressing my warm and lasting appreciation, but I thank you with all the sincerity of my nature.

Deaths During the Year

It is appropriate for me at this time to speak feelingly if briefly of our heavy losses during the past year by the deaths of Thomas D. West, of Cleveland, president in 1906, and a member of our Committee on Safety and Sanitation, and that on Emblem this year: Adam Bair, of Milwaukee, vice president in 1902, 1903 and 1905; C. A. Plamondon, of Chicago, chairman of the Local Convention Committee in 1913; B. J. Walker, member of the Committee on Foundry Costs during the past year; and E. H. Mumford, of Plainfield, N. J., for years an earnest working member of our association and a member of the executive board of the Exhibition Co. It was a pleasure and an honor to know and be associated with these gentlemen, who collectively have done an enormous amount of work for this association and for the advancement of foundry practice. Past President West continued up to the time of his tragic decease a very active and valued member of our board, and its sessions during this meeting have been saddened by the memory of him who was referred to as "Tommy" West, not in a disrespectful sense, but in an affectionate one. Our sympathy to the families bereft is as keen as is our appreciation of the particularly heavy losses sustained by our association during this eventful year. It is proper to refer to the recent death of Dr. Jos. A. Holmes,

director of the U. S. Bureau of Mines, valued friend of this and other technical societies which profited by his helpful co-operation.

Growth in Membership

I will not encroach on Mr. Backert's prerogative by giving you many details of statistical information, but I invite your attention to a few interesting facts. Following the excellent sample set by each of several recent administrations, we undertook a membership campaign on April 1. The time could not be considered as propitious from the standpoint of industrial conditions, and yet because it seemed the part of fairness to advise all foundrymen that entrance fees would be required after May 1, 1915, the board authorized us to undertake the campaign. This directly resulted in securing 43 active and 48 associate members, and much more than compensated for the expense of circularizing. The industrial situation which has existed for more than a year has naturally had its effect in retarding our numerical growth. This factor as well as that which involves entrance fees should be borne in mind in comparing our present roster with that of former years. It is very pleasing to announce that despite all handicaps, at the close of our fiscal year on July 1, 1915, we had 808 active members fully paid up, as compared with 760 on Aug. 1, 1914; and 150 associate members, 101 of whom came to us from the organization of the Associated Foundry Foremen, which was dissolved last January. As Secretary Backert's statement shows we have now reached the thousand mark in total membership. Our treasurer's report will show that we have a substantial fund to our credit, with all debts paid. All obligations throughout the year have been met with exemplary promptness. Your officers and board have diligently husbanded your resources, but Mr. Backert is the man chiefly responsible for your present gratifying financial condition. He should be very highly commended.

Committee Work

A departure will have been observed this year in the establishment of numerous standing committees. During the past twelve months no less than sixty committee members of

this association have been actively engaged in making investigations and tabulating data concerning problems which face the foundrymen of today. The results have been most flattering, and have proved that there was real need for such detailed work. A pleasing feature of such activity and one that speaks eloquently for the modern foundryman's attitude is the universal willingness expressed by those invited to serve on committees, in accepting such appointments. I beg to advise the continuation and extension of this policy in the firm belief that our members will thereby greatly profit.

It is with much satisfaction that I direct your attention to the greater interest now taken in our association by malleable iron founders. They, like the steel founders, have perceived the wisdom of allying themselves with our association, and of thus deriving the benefits secured by interchange of ideas. I would be ignoring an obligation if I did not publicly thank Vice President J. P. Pero Sr., who has had much to do with securing the more active co-operation with us of the men in the malleable industry. We are, I believe, rapidly nearing the time when we will fully accomplish the broad cardinal purpose of our association as defined in our constitution in these words: "The objects of this association shall be the advancement of the interests of foundry operators, or all who are concerned in the casting *of any kind of metal* in sand or loam molds, *for any purpose.*"

Cordial Relations With Allied Organizations

Our relations with our allies, the American Institute of Metals and the Exhibition Co., have been of the most cordial and mutually helpful nature. The Institute of Metals has thus far found it wise to continue as an independent, but related body, and is sensible of our kindly attitude of welcome, as exemplified in the instance of the absorption by us of the Associated Foundry Foremen. The Exhibition Co. has extended every consideration that could have been suggested throughout the entire year, and it has been fully demonstrated that a commercial organization can co-operate with a purely technical body in the most harmonious way towards an end sought by

both, and impossible of complete attainment by either acting alone. I take this occasion to publicly express my gratification at the courteous, helpful attitude of the officers of the Exhibition Co. as maintained throughout the year towards your officers. To more satisfactorily establish the relations between that company and your association, I recommend that you authorize your board to make such arrangements governing future co-operation with that representing the Exhibition Co. as may seem advisable. The spirit of co-operation which now inspires the various organizations interested in these conventions is most satisfying, and should be zealously fostered by all who have to do with either group.

The co-operative work performed by three of our important committees and those of similar character, representing the American Society for Testing Materials, has resulted in the discussion of specifications for gray iron, malleable iron and steel castings, which it is believed will find more popular acceptance than specifications previously drawn. We have found the Testing Society glad to combine forces with us in this matter, and believe an important advance step has been made. The relation of other technical societies toward ourselves was made closer during the past year through a suggestion to us from the Testing Society's Committee on Specifications for Coke that standard methods for analyzing coke be jointly worked out and adopted by the American Chemical Society, the American Society for Testing Materials and the American Foundrymen's Association. Your president, though not so empowered by the association, felt no hesitancy in appointing a committee which has had much profitable discussion with the committees from the other organizations. The standards that will eventually be suggested for your adoption will, it is hoped, serve the best interests of producer and consumer. This co-operative work augers well for the greater usefulness of our body and could, perhaps, be introduced advantageously into our safety propaganda by collaboration with the Conference Board on Safety and Sanitation, now representing the National Founders' Association, the National Association of Manufacturers, the National Metal Trades Association, and the National Electric Light Association. Such co-operation, I am assured,

would be welcomed by the organizations now joining forces in advocating "Safety First", and the pro-rated yearly expense which would be borne by our body, estimated at $350 a year, and restricted to a maximum amount of $500 annually, would, in my opinion, be justified at least for one year's experiment as soon as the state of our treasury permits.

Mention of co-operation with organizations should not be passed without reference to the fact that we were this year invited to join forces with more than 20 other scientific bodies in a movement to classify the literature of applied science. Thus far the expense of our participation in this work has been insignificant, but the results, it is thought, will be very valuable.

The secretary of state at Washington, and the director-general of the Pan-American Union have formally invited us to have an official delegate attend the sessions of the second Pan-American Scientific Congress to be held at the capital city from Dec. 27, 1915, to Jan. 8, 1916. Those in charge of this important enterprise desired early notice of the delegates' names and I accordingly advised that Past President Stanley G. Flagg, Jr., would represent us. Associations represented by delegates will not be assessed for a membership fee in the Congress.

Joint Board on Industrial Education

It has been suggested by the National Founders' Association that we co-operate with that body, the National Metal Trades Association, the National Association of Manufacturers, and the United Typothetae of America in the joint conference board on industrial education. The expense to each organization affiliated is now $100 per annum. There is some difference of opinion with respect to the methods to be pursued in furthering industrial training which in the abstract all progressive persons wish to encourage. And whether it may or may not seem best to the association that this organization join in the activities of the conference board, the knowledge that our participation is courteously invited is pleasing, as one of the many instances of the esteem in which this association is held by others. I advise serious consideration of this matter by the incoming board.

The invitation of the United States Bureau of Standards to us, to work with the bureau and other scientific bodies in making investigations, which was affirmatively passed upon by vote of this association during the present meeting promises well for our larger usefulness, and is the latest evidence of co-operation.

Your executive board acting fully within its powers decided during the past year that the association, like many other technical bodies, would gain a certain prestige by having a distinctive emblem. Accordingly a committee, headed by Mr. Backert, was appointed to take action, and numerous designs were prepared. It is hoped that the one selected will find favor, and that the pins will prove popular among our members. They can be obtained in black enamel and gold, by members only, from our secretary, at a very attractive price. In time they will doubtlessly be worn as extensively by our members as the pins of the engineering societies are worn by their adherents.

Committee Work Expense

It is natural for us on these occasions to consider how we may enhance the value of our organization to the members. As our financial condition improves many opportunities will present themselves, which will assist to this end. Our committee work could be much more effectively done if we might appropriate reasonable amounts for such use as in their judgment and that of your officers, might seem advisable. Our committee expense for the year past has totaled about $300—all that seemed wise to appropriate under prevailing conditions. If it were possible for more of our committees to carry on research work and for some of them to issue occasional bulletins approved by our officers, to all of the members, the educational value of the organization would be greatly enhanced. I sincerely trust that it will be found advisable during the coming year to undertake more investigations and some publicity work along conservative lines. The helpful feature of bulletins in organization work is attested by the reception accorded those relating to safety issued by the National Founders' Association.

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I have received and submitted to the board several proposals from commercial laboratories which hold membership in the association and which would be pleased to be designated as its official chemist, and as such to make investigations and determinations for this body, in return for the prestige attaching to the appointment. In my judgment an official chemist should be named when, but not before, there are assured facilities for systematic research work by a reasonable number of committees. It would be enlightening for the members to express their views on this matter, which, following some discussion, should, I think, be referred to the board with power to act when the time is deemed propitious.

The situation existing with regard to local foundrymen's organizations in several large centers, together with the need for closer relations between our body and its individual members, should make us consider if we may not soon apply the method of having local sections, which has met with much success in several engineering and scientific societies. Your president is aware of several local organizations of foundrymen which are having indifferent success. I offer for your future consideration, the suggestion that we ascertain the attitude of the various localized groups of foundrymen toward the idea of merging into local sections of the American Foundrymen's Association. This action, as it seems to me, would redound to the greater and better influence of centralized groups, and of the parent body. In voicing this opinion, I do not detract in the least from the very great usefulness and healthy condition of foundry organizations found in some of our cities. A necessary feature of this plan involves some financial and other aid from the national organization, whose ability to provide such is materially assisted by the larger membership resulting.

Tendencies to Consider

There are certain tendencies characteristic of this era of efficiency that we, as foundrymen, should consider in sober-minded fashion. Shops where metals are cast are and should be tremendously concerned in the present widespread movement for the highest industrial development. It may perhaps be truthfully stated that foundries have even now more knowledge

to acquire in the attainment of efficient operation and the intelligent selling of the product than do many other manufacturing businesses. Foundries have made vast progress in the two decades that have passed since our organization was formed. We still have much to learn from more highly developed lines of industry. Time was in our own recollection when molding methods were of the crudest; when fractures governed the purchase of pig iron; when mixtures were largely matters of guesswork and superstition; when foremen were selected with much thought as to their imposing height and muscular development; and when even in the days of our own association, such gatherings as these were the occasions for much more sociability of questionable wholesomeness than for the exchange of useful information. We have attained at the beginning of this, the twenty-first year of our existence, the stature and wisdom of vigorous manhood, and can regard certain characteristics of the past as the errors of youth, now outgrown for all time.

In adapting ourselves to our higher plane of thought and deed, and in properly striving for the greatest efficiency, I venture the suggestion that we proceed along sane, conservative lines. Human nature is such a peculiar attribute that it frequently urges us to go from one to the other extreme. There seems to me some risk that we may carry our measures for efficient operation too far, if we do not make careful analyses of causes and effects. Specialization may be overdone and can do great injury to plants and workmen if not skillfully kept in proper bounds. It is essential that we keep in mind the highest development of workmen as well as machines, and avoid making these terms synonymous. If we do not, we will surely and justly suffer from a dearth of skilled mechanics. I was once informed of a workman whose sole task consisted of pressing the treadle of a machine with his right foot. The operator's task gradually gave him an abnormal development on one side of his body, and this was finally so apparent that it was regarded as a humorous matter until the tragedy of the situation dawned on those responsible. The average workman of today argues that the manufacturer is constantly striving to displace men with mechanism. The progressive plant owner will admit the necessity for utilizing mechanical devices wherever

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these may profitably supersede manual labor, in order that he may meet competition. The intelligent buyer favors the mechanically produced article, in the belief, in the main correct, that it is more accurately made. But the whole trend of industrial progress creates a greater need today for skilled mechanics in greatly diversified lines than ever before existed, and I think we want to take good care of our craftsmen and help to make them better ones. Further, we should, as wisely recommended by our Committee on Industrial Education, aggressively but tactfully do all that we can towards creating in our schools, a source of supply of intelligent workmen. We do not want to get rid of the skilled mechanic, but rather do we need to apply his trained hands and mind to work that they can best do, and to gradually develop him in all ways that may enable him to better himself and ourselves. Specialization is necessary, but it has its own limitations, if we give proper heed to our future need for skilled workmen as our processes develop and if we do not have solely in mind the immediate present.

Proper Selection of Employes

In properly selecting employes with regard to special fitness, and in maintaining such shop regulations as we believe will conduce to their mental, physical and moral well-being, I venture to advise a more conservative attitude than sometimes exists. The most efficient organization cannot in my opinion be in that plant where the men are expected to be nervously "on their toes" for every minute of time while they are on duty, and where there is not reasonable tolerance in little things. Man is so constituted that he needs throughout each day, whether he figuratively pulls a plant whistle or literally wields a shovel, occasional movements of partial relaxation. And we act unwisely, indeed inefficiently in the final analysis, if we do not take into full account the human element in man, imperfect as it may be in many respects, but ever present, as it certainly is.

This thought with respect to workmen impels me to hazard an expression concerning foremen. It has lately seemed to me that many of us have maintained a rather unjust and thoughtless attitude toward our foundry foremen and their

assistants on the molding floor and in the core room. Do we often stop to think of one of these except from the standpoint of the amount and quality of work he can get out of his men? Do we pause to consider the thanklessness of the foundry foreman's job, day in and day out? Have we often given him opportunity for hope that he may aspire to better things in this age when technical men are much in demand for higher executive positions in our business? Under ordinary circumstances when we need an assistant foundry foreman, we select a dependable skilled molder. Formerly when a superintendent was wanted, a head molding foreman of proven mechanical and executive ability was often promoted. In later years, not a few of the many ambitious technical graduates from our colleges happily have looked to the foundries as likely places for advancement, and a suitable field for the application of their theoretical knowledge. We find good use for many such, but frequently along special lines that do not provide the closest knowledge of operations distinctly peculiar to melting, molding and coremaking. When we require an assistant for general plant supervision, we are much more apt to select the young engineer than the foundry foreman, who is frequently left to the sand heap and his own salvation until he gets too old for the job, and wearies of his undeniably annoying responsibilities. Judging by modern methods of selection in promotion, the foreman should be given opportunities that he does not, according to my observation, at present enjoy in some foundries. And looking at the situation from the viewpoint of efficient production, I admit to being one of those who yet strongly believe that actual experience in getting one's own hands into things, and the ability to personally and satisfactorily perform operations that are given one to oversee are very important elements of preparation for executive work, not always essential, but invariably desirable. I know from my limited experience that wonders can be done along educational lines with foremen of middle age who had the advantage of only a half dozen years at school. A most creditable knowledge of mechanical drawing can be acquired by such men, when it is tactfully presented, and the value of these foremen to the plant organization is thereby greatly increased with slight direct

expense, which may well be disregarded in consideration of the lasting benefits secured. This association wants to do all in its power to help the foreman, both as an organization and in the personal spheres of its individual members.

The Consulting Foundry Specialists

I have referred to efficiency as applied to workman and foreman. A few comments concerning the consulting foundry specialist are apropos. That this individual has a legitimate function to perform in modernized founding is granted by all who consider the matter impartially. There are persons whom nature has not supplied with that amplitude of patience needed for the performance or supervision of routine affairs, but whose ready perception, ability to develop possibilities in previously untried methods, and temperament for analytical study of mechanical and scientific problems admirably fit them for experts to be engaged for working out special processes, or bringing to light obscure causes for trouble. It is well that such persons are available and it is not to their discredit that they may be jokingly referred to as "efficiency doctors". Their greatest handicap seems to me to lie in themselves, and to be due to personnel. Expressing the proposition plainly, there is among the self-advertised exponents of efficiency a regrettable number of pseudo-experts who have failed to make good at specific tasks in the foundry business, and who have entered the consulting field as promising better returns to those who have the faculty of talking well and magnifying the importance of their personal knowledge to credible foundrymen in difficulties. One of these individuals after a half-hour's hurried walk through a large foundry that he never saw before, comfortably seated himself in the manager's office and delivered himself of the definite statement that the foundry was being operated at 70 per cent of its efficiency. Another confident gentleman publicly advertises: "You get immediate results and begin at once to make savings on fuel, material, etc., bettering the product 24 hours after consulting me. You make no experiments. Every foundry needs our facts, figures and efficiency methods." And still another, throwing self-effacement to the four winds, is responsible for this astonishing printed

notice: "If you are having foundry troubles consult me, the man who knows foundries from A to Z. No matter what the question is, if it pertains to the foundry, I can solve it and save you money. There is absolutely nothing in connection with foundry work of which I am not thoroughly master." It is to be regretted that there is not universally among consulting men in this field that ethical point of view which exists among consulting experts in many other lines of endeavor, and which serves to discredit exaggerated claims, difficult or impossible to substantiate. We as foundrymen can advance our own interests and can be of service to those foundry experts who are of real help to us, and whom consequently we are glad to occasionally engage, by strongly discouraging absurd claims, and by warning the unwary foundryman in trouble to beware of the personage who has learned it all.

Advances in Foundry Practice

Our honored former secretary, Dr. Moldenke, presented at one of our sessions a resume of advances in foundry practice. A review of this sort cannot fail to convince the most critical that there has been a great development in our industry in recent years. During the present generation there have been such revolutions in the cost of production of cast metals of all kinds that a brief story of this progress has all the interest of magic for its readers. Within the recollection of some of my hearers aluminum, which before the present war was quoted at 22 cents, sold for $90 per pound, and steel castings which now sell frequently under 3 cents per pound, were never purchased 60 years ago for less than 12½ cents per pound. Metallurgical processes have indeed wrought wonders in making available for man's daily use, those ferrous and non-ferrous alloys which take definite form in molding sand. The development of the foundry is a most important feature of the social and industrial advancement of the human race. On the American continent, as in Europe, tyranny has been overthrown in the past mainly by the use of castings in various forms. The venerated bell which has its permanent shrine so close to us, and which rang out in 1776 the declaration that the American people would henceforth exist only as an independent nation,

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was born in a humble foundry and was literally cast three times before its makers were satisfied with its qualities. Paul Revere in his own day achieved more fame in casting and forming precious metals than in making his historic midnight ride. The beauty of art, the sentiment of commemorative objects, the utility of present day necessities of domestic and industrial life, are in enormous degree the products of the industry of which we are servants. The sand pile has indeed fulfilled a useful and honorable mission. How can we doubt that in future years, the art of casting metals will make much greater strides than in the past? Foundry scientists were never before so numerous and so practical as today. We are rapidly acquiring a very comprehensive knowledge of the peculiarities of the elements and their behavior when placed in combination with each other. Certain characteristics which they possess are today little understood, but the problems that remain unsolved are being vigorously attacked. One question which now puzzles the brains of founders and others is that which may determine the cause and remedy for what is sometimes termed "strain-disease", or the decay of metals apart from corrosive action. Another conundrum is found in the need for molds of permanent nature, in seeking which large sums have been expended, and profitably so in certain restricted fields. Who can say that in the future we may not find means of largely eliminating the shrinkage which occurs when molten metals solidify, and thus at once remove the barrier which is imposed against the adoption of molds of inflexible and indestructible nature, and coincidentally cause to vanish that *bete noir* of foundrymen, the shrinkage crack?

For results already achieved, and those we look for, we as foundrymen do not and will not claim all the credit. The parts played by the mechanical and electrical engineers in the wonderful development of processes in the foundry have been of immeasureable importance, and will continue so to rank. In no small degree are we indebted to the makers of alloys and to those purely scientific investigators who are not commercially identified with the casting of metals. The larger foundries happily have today in their service a great number of technical experts and metallurgists of ability. Such men

working in conjunction with those having practical knowledge of foundry conditions are developing research work along constructive lines which promises much for the future. It is not a matter for surprise that the intensely interesting and to some extent mysterious transformations that daily occur within the prosaic walls of the foundry have drawn to us such intelligent and inquiring minds, that gradually our occupation as foundrymen has been elevated from a mere calling, as it was regarded yesterday, to an honored profession, as it is acknowledged today. I believe I am voicing the thought that is now in your minds when I say that the main factor in all this advancement, this search for knowledge, this growth in personnel, this exchange of ideas, which, combined have brought about the present gratifying conditions, and which promise so much for tomorrow, has been our own organization. That simple statement needs no reiteration or embellishment. Foundrymen must admit its truth, and in the admission feel honest pride in, and renewed loyalty to the American Foundrymen's Association.

Discussion

MR. R. H. SWEETSER:—In the President's report, which was very interesting and able, a suggestion was made that I think will find co-operation in a good many sections; that was regarding the co-operation of the American Foundrymen's Association with people in actual business and people who are connected with the technical side of the foundrymen's work. In the east there is a desire on the part of one of the colleges to co-operate with the practical work in a manner something after the work that is being done in Cincinnati. That suggestion has been made by the head of one of the departments and they are now looking for a practical method of carrying out that scheme. The plan is something like this: they will have

a continuous course of 50 weeks, in the evening, and the men taking this course in mechanical, civil, or chemical engineering will be in pairs and there will be one student from the college and one student in the works of the different organizations who will co-operate. For instance, a pair of students will take up a four years' course in the college and one of the students will be in some foundry, machine shop, metallurgical plant, rolling mill, or blast furnace for two weeks and his partner in the college for two weeks, and then the next two weeks they will just change positions, so that each industry will have a student apprentice working all the time and the college will have a student, so that the work of the student will be carried on in such a way that he will get his practical training and his technical training at the same time. I represent one of the industries ready to co-operate in this plan, and I do not feel like saying anything about the college, because I would rather they would speak for themselves; but the plan seemed so good that I believe it could be carried out in different parts of the country, and I think that the suggestion of the president could be put into practical operation. I think that a great many young men would like to take a course of that kind, especially men who don't have enough money to see them through a technical course of four years. If they start in this way, they will probably start at a laborer's wage, and their wages will be gradually increased, and by the time they have finished that four years' technical course, they will have some sort of a trade and will have served their apprenticeship. I think this scheme can be put into practical operation.

THE CHAIRMAN, MR. R. A. BULL:—One of our own members, Mr. C. E. Hoyt, who is also secretary of the Exhibition Co., if he were here could probably give us some interesting information along that line, because the Lewis Institute, with which he is connected, has employed that co-operative plan for some time with considerable success. Mr. Hoyt is in charge of that particular work at the Lewis Institute. It is a plan, that, I think, Dean Snyder, had a good deal to do with starting and has been very successful in a number of communities, not only privately endowed schools, but public schools. I think we might all give considerable thought to that matter, applying the

plan in such a way as to promise success in our different localities. Different localities have their own peculiarities and each man in his own town must apply the conditions that best suit local needs.

MR. J. P. PERO:—In Fitchburg, Mass., they have been working on that plan in their high schools for several years very successfully. They have an academic high school where a boy takes the academic course in preparation for college. Fitchburg is a city of iron workers and mechanics, and one of the courses in the high school takes care of those young men who want to learn different trades, and they are indentured apprentices during their high school course, devoting one week to school work and one week to shop work. If you want any information, you can get it from Fitchburg readily, because that plan has been working successfully there for several years.

THE CHAIRMAN:—Are there any further remarks? We are fortunate in having present Mr. W. H. Barr, president of the National Founders' Association. It is possible that some of you might like some information concerning the two conference boards which I mentioned in my report, one on safety and one on industrial education. If so, I am sure he will be very glad to enlighten you.

MR. W. H. BARR:—Mr. President, I thank you very much for the opportunity. I have been attending your meetings and I have been exceedingly interested in the various papers that have been presented and have been impressed tonight with the summing up offered by President Bull. I have been very much gratified, in the last two or three years, to notice the increasing desire for co-operation of every kind on the part of the foundryman, and, for that matter, manufacturers of every description. It seems to me that there are distinct possibilities for furthering our mutual interests if we can focus more acutely on those particular things that are of interest to both associations. Too much cannot be said of the work that is being done by the American Foundrymen's Association. I appreciate that a great many members of this association can be members of our own, but on the other hand, I feel that there is not a member of our association who cannot, with profit, become a member of the American Foundrymen's Association, and to

assist actively in furthering the work you gentlemen are doing and which redounds to the advancement of our industry. In the last two or three years our association has recognized the necessity for a broader field of activity than in the old days, and as we still are conducting an open shop organization looking to the advancement of employes, we realize that that field of endeavor could be extended by trying to reach the root of some of the things that affected relations between employer and employe and to that end we have gone into the question of safety and sanitation thoroughly and, I think, exhausted it. We are now actively engaged in the apprenticeship question, a subject that has a wide range, and we now have on foot a rather comprehensive national plan for legislative co-operation which will perhaps be participated in by a number of national associations; but the point on which these two associations come in contact and where they should work to their mutual advantage, it seems to me, is under the heads of safety and sanitation and apprenticeship, or educational trade training, or whatever you please to call it. About two years ago, the four associations which President Bull has enumerated—the National Founders, the Metal Trades, the Electric Lighting and the Manufacturers—appointed a joint conference board consisting of the president and two members from each association, who comprised this board, and during two years we have actively discussed and investigated the subject of safety and sanitation, and I think we have progressed to a point, in the foundry investigation at least, where we should be assisted by the advice and co-operation of a committee from this association. The subject is a large one. We cannot have too many active minds at work on the problem, and we very cordially extend to this association an invitation to join that conference board. As Mr. Bull has stated, the cost varies from $350 to $500 a year, and that money is used for research work, for the publication of bulletins, postage, etc. The secretary works without salary and there are no expenses which are not directly connected with the work of the board. The field has been pretty thoroughly covered and we have issued a good many bulletins, not alone for our association, but for the benefit of all foundrymen, and we are very glad indeed to turn over the results of our investi-

gations in foundry sanitation and safety to this association to be used for the benefit of every foundryman in America. We feel that the broad plan on which we are working is the proper one and we earnestly hope it will have your support. We have not progressed quite as far in apprenticeship work—that joint committee has been in operation less than a year—as have the Typothetae, who perhaps have progressed further than any of the other national associations in apprenticeship training, and they really have it down to a science or nearly so. The benefit of their advice is going to be of value to us in preparing a series of classes of education for the various industries which are represented on that board and which would like, in that work, the advice and assistance of your able committee for the development of the plans. And, by the way, I will say that this joint committee represents firms employing about 5,000,000 employes. With the addition of the members of this association, that number would be increased, and it seems to me that when we have properly decided on this series of educational plans, that it will be an extremely simple matter to secure the co-operation of every public or private institution for the education of young men, and, for that matter, of young women. I accordingly invite you to join, on behalf of this board or joint committee, and I hope that your directors will see fit to consider it in a favorable light. The details are almost too numerous for me to enlarge on at this time, but if there are any questions you gentlemen would like to ask in reference to the work of either of these joint conference boards, I would be very glad to try to answer them.

THE CHAIRMAN:—Mr. Barr, do I understand that the plan is to issue bulletins to be sent to the members of the various associations on safety, or are those bulletins issued by the individual association?

MR. W. H. BARR:—At the present time, the bulletins are issued by the individual associations. Any association wishing to have the approval of the board, submits it to the secretaries or the chairmen of the sub-committees comprising this joint conference board and they give it their approval, and when that is had, it is issued under the approval of the "Naso Board," as we call it, so that while the conference board will approve any

pamphlet you wish to have approved for the benefit of the association, it does not, in any respect limit you in the publication of pamphlets of your own. We hope that the movement may progress to a point, where at some time, without any increase in expense, we may have a paid man to write the bulletins for the various associations, and perhaps conduct them on a more comprehensive scale than has so far been undertaken. That is in the future, and is a development which your active participation might further.

THE CHAIRMAN:—I am sure we are very much obliged to Mr. Barr for making these explanatory remarks, and our board will be very glad to remember them and read them over after they are transcribed by the secretary, and give them careful consideration on passing on these important questions.

MR. W. H. BARR:—We will be very glad to give your board or secretary any information you want or answer any questions, but I do hope we can get together, because it means so much to the industries, and there is no question that co-operation is the order of the day, and we owe it to ourselves to neglect no opportunity for the furthering of our business in the future.

THE CHAIRMAN:—I would like to suggest, as an appropriate thing to do in the matter of the suggestions that have been made concerning all points touched upon by myself and Mr. Barr and other speakers—that they be referred to our executive board with power to take whatever action may be deemed advisable. That would be really according to the regulations of the constitution, but it would not be out of place to make it a matter of record at this session, I think.

It was moved and carried that the matters suggested in the papers and reports presented Wednesday evening, Sept. 29, be referred to the executive committee with power to act.

MR. W. H. BARR:—May I offer another thought?

THE CHAIRMAN:—Yes sir.

MR. W. H. BARR:—In furthering this effort at co-operation, I am of the opinion that our association would very probably assist, if your committee wishes, in the development of this plan which I heard discussed today, for a foundry expert or

cost expert, as outlined in the report of that committee. In talking with Mr. Koch a few minutes ago, I told him that I could conceive of no objection on the part of our council to sending out throughout our membership, the reports issued by your committee containing its suggestions, with an appropriate letter urging our members to assist in this plan should you care to have them do so. Undoubtedly there are a great many members in our association who are in need of cost development work in their plants. Some of them may not belong to the American Foundrymen's Association, but it would be a step in that direction which we would be very glad to take if you are inclined to have us.

Annual Report of the Executive Board

To the Members of the American Foundrymen's Association:

During the past year the members of your executive board have received thirteen communications from your president relating to the conduct of the affairs of your society. Immediately following the close of the 1914 convention at Chicago a letter ballot of the members was taken on the change in the constitution and by-laws, the principal provision of which classifies the membership as active, associate and honorary, and provides for the payment of $10 per year dues for active and $5 for associate membership. In addition, since May 1 this year an admission fee of $10 has been charged for active and $5 for associate membership. Associate members have all the rights and privileges of active members except the right to receive gratis the *Transactions* in bound volume form. Associate members, however, receive gratis, pamphlet copies of pre-printed original papers read at conventions. The vote in favor of this change was almost unanimous and the constitution and by-laws in their revised form were published in the association's *Year Book*.

Affiliation of Associated Foundry Foremen

The affiliation of the members of the Associated Foundry Foremen with the American Foundrymen's Association was effected on Jan. 1, 1915, when 101 members of the former society were enrolled as associate members of the American Foundrymen's Association. The balance in the treasury of this association, amounting to $20.32, was transmitted to your treasurer and was credited to the funds of your association. These associate members were permitted to affiliate with your society without the payment of dues until July 1, 1915.

Your executive board appointed a sub-committee, consisting of the president, senior vice president and the secretary, to decide upon the time and place for the 1915 meeting. This

committee met in Cleveland on Saturday, Oct. 24, with a similar committee of the Foundry & Machine Exhibition Co., the American Institute of Metals having been represented by proxy. As a result of this meeting and further negotiations, Atlantic City, N. J., was selected as the place for the twentieth meeting of your society.

During the past year an emblem committee was appointed, which consisted of A. O. Backert, R. A. Bull, the late Thomas D. West, B. D. Fuller and H. Cole Estep. Numerous designs were submitted and the emblem with which you are familiar was selected. The emblem also has been struck off in the form of a button in black enamel with a gold background, which can be obtained from the secretary at a nominal price.

Meetings of Committee on Papers

A meeting of the members of the papers committee who were conveniently close to Chicago at that time, met in that city Jan. 30 and discussed this important phase of convention work. The meeting was attended by R. A. Bull, A. O. Backert, H. B. Swan, J. P. Pero, Jr., and O. J. Abell. A tentative program was outlined and a departure in the time of the principal business session was made. It was concluded to have this meeting the middle of the week instead of at the final session in view of the fact that the new president and new board are handicapped by having little opportunity to get together after election to discuss association policies and to confer with the officers of other organizations interested in our meetings. Other meetings of your sub-committee with the chairman of the papers committee were held at Chicago, July 4 and Sept. 5.

A membership campaign was authorized during the month of April. All foundrymen in the United States and Canada, not affiliated with your association, were invited to join prior to May 1, when an admission fee of $10 for active and $5 for associate membership became effective. Approximately 10,000 letters were mailed, and as a result of this campaign 45 active and 48 associate membership applications were received. The dues from these new members totaled $670, whereas the cost of the campaign was only $350, netting a profit to the association of $320.

Since the 1914 meeting, a committee on coke analysis was appointed to co-operate with the American Society for Testing Materials and the American Chemical Society. The personnel of this committee follows: H. E. Diller, General Electric Co., Erie, Pa., chairman; R. S. McPherran, Allis-Chalmers Mfg. Co., Milwaukee; J. B. Stoddard, Detroit Testing Laboratory, Detroit; A. S. Hummel, Taylor-Wharton Iron & Steel Co., High Bridge, N. J.; Paul Debevoise, Debevoise, Anderson & Co., New York, and Dr. Richard Moldenke, Watchung, N. J.

Your executive board authorized the audit of the books of your association by Ernst & Ernst, certified public accountants, of Cleveland. Heretofore a committee has been appointed at the annual meeting to audit the books, but the employment of a certified accountant obviates the necessity for making this investigation at the time of the conventions. Your treasurer also has been put under bond.

To ascertain the views of all of the members concerning the preference for Spring or Fall for holding the annual conventions, a letter ballot was authorized. While the constitution places in the hands of the board the decision as to time and place for each annual meeting, the board wishes, as far as conditions permit, to be guided by the convenience of the majority in arranging for the time of conventions following the 1915 meeting. A majority of those who voted favored Fall meetings. The result of the letter ballot follows: In favor of September or October, 38; in favor of May or June, 24; no preference, 2.

It is with sorrow that we officially record the decease, since our 1914 meeting, of Past President Thos. D. West, an active member of your executive board. Mr. West was held in the greatest esteem because of his sterling character, and because his career was of such great value to others in the foundry business, your board has authorized the preparation of appropriate resolutions referring to this great loss to the association.

Respectfully submitted,

A. O. BACKERT, Secretary Executive Board.

R. A. BULL, Chairman.

Annual Report of the Secretary-Treasurer

To the President and Members of the American Foundrymen's Association:

Trade conditions which were exceedingly unsatisfactory in the foundry industry during the past year, fortunately were not reflected in the growth in membership and prestige of your association. As a result of the active campaign conducted for new members the enrollment on July 1, totaled 996, a gain of 213, or 28 per cent in 11 months. Your constitution and by-laws, revised by an almost unanimous vote, now provide for an admission fee of $10 for active and $5 for associate membership. Prior to May 1, this year, however, applications were received without the payment of the admission fees and during the month of April, when a campaign for new members was carried on, 91 were enrolled, 43 active and 48 associate. By the affiliation of the paid-up membership of the Associated Foundry Foremen with the American Foundrymen's Association, 101 associate members were added. The resignations totaled only 31 during the year, or slightly over 3 per cent; four members were dropped for non-payment of dues and there were five deaths.

The membership data, at the end of the fiscal year, June 30, 1915, follow:

Active members, good standing	808	
Active members, delinquent	23	
Active members carried on books		831
Associate members from A. F. F.	101	
Associate members, new	49	
Associate members on books		150
Honorary members		15
Total book membership		996
Total membership paid up to July 1, 1915		973
Total membership, Aug. 1, 1914		760
Gain in 11 months, 28 per cent or		213
Deaths during the year	5	
Resignations during the year	31	
Dropped for non-payment of dues	4	

New members received during April, 1915, 91, of which 43 were active and 48 associate.

The number of delinquents at the end of our fiscal year was somewhat larger than in former years, due largely to depressed trade conditions, and your secretary-treasurer was authorized to carry their names on the books for a brief period. The extension of time thus granted for the payment of dues has resulted satisfactorily and there is every indication that all of the accounts will be collected, leaving these delinquents in good standing and the total membership correspondingly increased thereby. No dues were collected from the associate members formerly affiliated with the Associated Foundry Foremen, until July 1, this year.

The following deaths occurred among the members during the year:

Zachary Taylor, Taylor & Co., Brooklyn, N. Y., Feb. 18, 1915.

E. H. Mumford, E. H. Mumford Co., Elizabeth, N. J., April 18, 1915.

B. J. Walker, Erie Malleable Iron Co., Erie, Pa., April 29, 1915.

Geo. H. Russell, Russell Wheel & Foundry Co., Detroit, May 17, 1915.

Thomas D. West, West Steel Casting Co., Cleveland, June 18, 1915.

Accompanying this report is a chart showing the growth in membership of the American Foundrymen's Association since the date of its organization in 1896.

Finances

It is exceedingly gratifying to report that your association is in better condition financially than at any time in its history. The appended financial statement of Ernst & Ernst, certified public accountants, showed a balance in the treasury of $1,116 on July 1, 1915, as compared with $75.83 July 1, 1914, a gain of $1,040.17. The total receipts from dues, subscriptions, sale of books, pamphlets and emblems, totaled $8,779.70, as compared with $6,391.14 from July 1, 1913, to July 1, 1914, an increase of $2,388.56. The disbursements amounted to $7,739.53, against $6,315.31 the previous year, a gain of $1,424.22. From the Associated Foundry Foremen was received

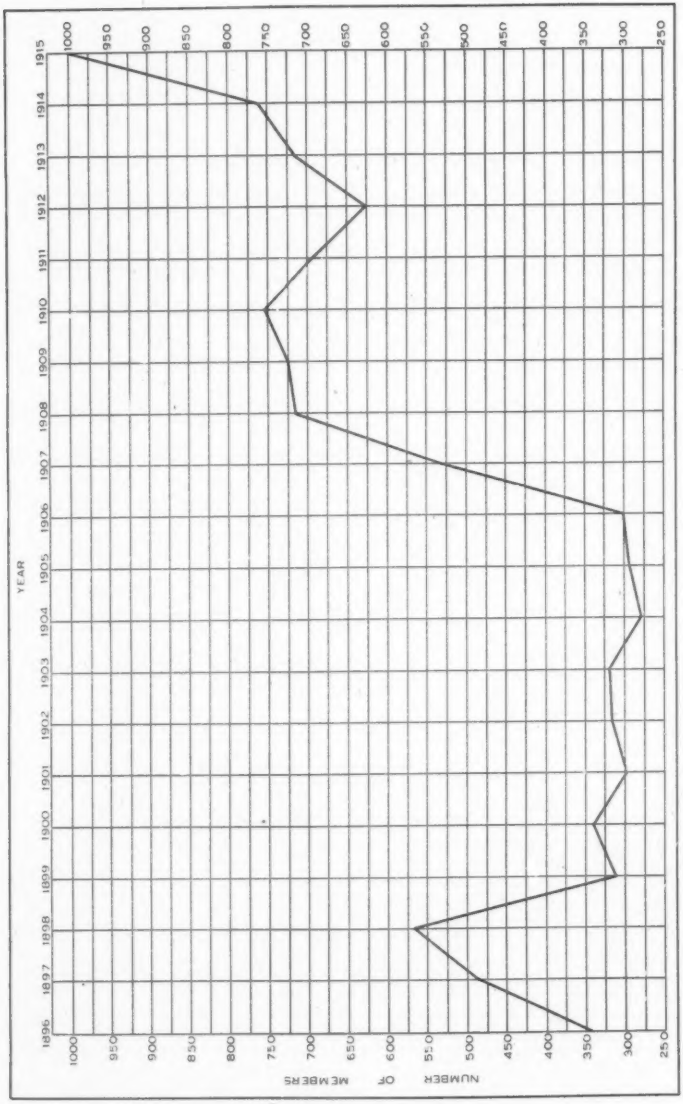


CHART SHOWING GROWTH IN MEMBERSHIP OF THE AMERICAN FOUNDRYMEN'S ASSOCIATION

$20.32, representing its balance in the treasury at the time of the affiliation of this organization with the American Foundrymen's Association.

For the hearty support of the officers of your association, your executive board, committees and the membership at large, which greatly lightened his duties, your secretary-treasurer extends his sincere thanks.

Respectfully submitted,

A. O. BACKERT, *Secretary-Treasurer.*

Treasurer's Report

Cleveland, Aug. 20, 1915.

Mr. A. O. Backert,

Sec'y and Treas., the American Foundrymen's Association,
Cleveland.

Dear Sir:—In accordance with your instructions we have audited the cash receipts and disbursements of the American Foundrymen's Association for the year ended June 30, 1915, and submit herewith our report.

Below is set forth a summary of the cash transactions for the period under review:

CASH BALANCE as shown by the association's records July 1, 1914			$ 75.83

Transactions for the Year.

RECEIPTS

Dues, subscriptions, etc.	$8,739.70		
From Sale of Emblems	40.00	$8,779.70	

DISBURSEMENTS

Administrative salaries	$1,200.00		
Clerical salaries	798.85		
Office expense	78.96		
Printing	3,868.23		
Postage	779.98		
Convention expense	632.02		
Traveling expense	269.91		
Furniture and fixtures	34.08		
Emblems	67.50		
Dues overpaid and returned	10.00	7,739.53	
Receipts in excess of disbursements			$1,040.17
			$1,116.00

Cash on Hand and on Deposit.

On hand	$ 89.55	
On deposit	1,026.45	
		$1,116.00

Cash on hand, amounting to $89.55 on June 30, 1915, was verified by tracing same into the bank deposits subsequent to that date and cash on deposit, amounting to $1,026.45, was verified by officially signed statement from the Central National Bank, the association's depository.

We traced all recorded cash receipts for the period under audit directly into the bank deposits and found all cash disbursements to be supported by properly signed and cancelled bank checks, together with invoices, receipts and other supporting data on file, with the exception of check No. 88 for $24.17, which has been paid by the bank, but was missing from the association's files.

As part of our work we checked the cash received for dues directly to the individual members' accounts and have prepared and include as part of this report an exhibit setting forth in detail active and resigned members whose dues remained unpaid on June 30, 1915. We did not, however, correspond with the individual members for the purpose of verifying the accuracy of the association's records, and our report is submitted subject to this exception.

Inventories submitted to us showed that the association had supplies, fixtures, etc., on hand as follows:

Printed matter	$825.00
Furniture and fixtures	34.08
Emblems	27.50
Total	$886.58

No liabilities were disclosed by the association's records or reported to us.

Very truly yours,

ERNST & ERNST,
Certified Public Accountants.

Cash Receipts and Disbursements

The American Foundrymen's Association, June 30, 1915.

CASH BALANCE—as shown by the association's records July, 1915			$ 75.83

Transactions for the Year.

RECEIPTS

Dues, subscriptions, etc.	$8,739.70		
From sale of emblems	40.00		
Total receipts		$8,779.70	

DISBURSEMENTS

Administrative salary	$1,200.00		
Clerical salaries	798.85		
Office expense	78.96		
Printing	3,868.23		
Postage	779.98		
Convention expense	632.02		
Traveling expense	269.91		
Furniture and fixtures	34.08		
Emblems	67.50		
Dues overpaid and returned	10.00		
Total disbursements		$7,739.53	
Receipts in excess of disbursements			$1,040.17
Cash to be accounted for			$1,116.00

CASH ACCOUNTED FOR

On hand	$ 89.55
On deposit	1,026.45
Total	$1,116.00

Proceedings and Recommendations of the A. F. A. Cost Committee

Since its appointment at the Chicago convention in 1914, the members of your cost committee have held a number of meetings and conferences with a view of compiling a report that at the same time would be simple, yet sufficiently comprehensive for satisfactory application to cost accounting in almost every casting plant. The report of the committee and its recommendations form a separate section of this pamphlet and will be found on page 61. In the early consideration of this subject it was agreed that a uniform basis of figuring costs should be adopted and this recommendation is made in the committee report.

It is self-evident that ruinous competition is as much the result of the lack of uniform cost as the lack of no cost. Furthermore, it is apparent that by the universal adoption of a uniform basis for figuring cost, competition will be placed on a more equal basis than at the present time. The need for a uniform cost system among foundries was pointed out by A. O. Backert in his paper entitled "How to Estimate the Selling Price of Castings", and by F. J. Stephenson, who discussed the subject "Shall a Manufacturer Figure Costs Before Fixing His Selling Price?", both of which were on the program of our last meeting. It is suggested that every foundryman again read and digest both of these papers, and to emphasize the epigrammatic paragraphs a number have been selected, as follows:

Mr. Backert says: "The replies received indicate a wide variance of methods." Then note the different replies, some good, some bad, others humorous, such as "What we can get and by experience", which was in answer to the query "How do you estimate the selling price of castings?". It also was ascertained that some employers have an estimating department while others do not.

The best reply to the inquiry "What percentage does your overhead expense bear to your labor cost?" was "Average for five years 114 per cent". This percentage is truly representative of this period, as it includes years of prosperity and periods of depression. If a period be taken only for one year and if that happens to be an unusually prosperous one, the overhead expense naturally would be smaller and the percentage would be too low for use in estimating a selling price. On the other hand, if an average be taken for a poor year, the overhead expense would be larger and the percentage would be too high for consideration in fixing a selling price. In the first instance the customer would derive too great a benefit while in the second, the price estimated will be too high. Therefore, it is apparent that to obtain a truly representative percentage of the overhead expense in comparison with the labor cost, a period must be considered that will include both fat and lean years.

One of the foundrymen replying to the series of questions submitted by Mr. Backert stated that "Sand is included in the overhead", indicating that he did not realize that the consumption of sand fluctuates in accordance with the tonnage of castings produced. It might be stated that an overhead charge should include all regular constant charges regardless of the amount of business that is done, as well as the special charges aside from material or labor, which should be charged direct to each department. It is interesting to note the questionable items that are included in overhead in Mr. Backert's report, such as melting cost. Is this not a direct charge to be made to a department to ascertain the direct or actual cost of the metal? If every foundryman would figure the same as the one who replied on the subject of the cost of metal—"We go on the assumption that molten metal is delivered as though it came from some outside shop"—a large part of the problem would be solved. The last paragraph contained in Mr. Backert's report also should be read carefully.

Also read and digest the following epigrams on cost accounting taken from Mr. Stephenson's valuable paper:

"Costs will always vary with economic conditions".

"Not uniform methods, but uniform theories".

"First commercial costs, second control costs".

"A safety device which would prevent him (your competitor) from selling $1.00 worth of goods for 90 cents".

"If he had a higher overhead he could not sell his goods".

"Costs are cold-blooded business propositions".

"If he figured too low, he did not want to know the cost".

"Increasing the volume by cutting the price does not always lower the cost".

"We knew a glove manufacturer who was losing 50 cents per dozen and, therefore, he doubled his volume of business and decreased his cost 25 cents per dozen. How much did he save by his brilliant idea and hard work?"

"Costs are determined to mark the danger line".

"Your cost figures represent your danger line".

"He will believe his own figures".

"Include administrative and selling expenses".

"He made money under his old methods" should be "in spite of his old methods".

"No system of cost keeping is free from weakness".

"Overhead charges of necessity are distributed on a theory, they are merely opinions".

"How much better off both would be if they figured the same way".

"You cannot formulate a law (or costs) which completely covers every phase".

"It is necessary to qualify—to meet unusual conditions—seek uniform results".

"Exempt one portion of overhead, you place excess on the remainder of your product".

"Cost system shows naked truth".

"Simple system adopted by all".

"Manager should know why—bookkeeper how".

"Not necessary to worry—to provide a system so perfect to comprehend all costs".

"You can do it if you try to settle a few theories".

"Live up to them".

"Instead of arriving at different results".

"A good man starting perhaps as a cost man and developing according to your demands will be an investment worth probably more to the foundry industry than any undertaking which you may consider".

"It will tend to strengthen the entire industry by eliminating not only competition due to ignorance of costs, but competition due to differences of opinion as to what are the costs".

"Establish a method approximately correct and all abide by it".

Your committee, in its report, has endeavored to establish a method approximately correct and if adopted, it recommends that all foundrymen abide by it. It should be explained in this connection that the bases or theories recommended can be amplified to meet varying conditions.

For their valuable suggestions and assistance in the compilation of this report, your committee makes grateful acknowledgment to the following: Roy Tanner, Pittsburgh Valve Foundry & Construction Co., Pittsburgh; F. J. Stephenson, cost expert, National Association of Stove Manufacturers, Hoosick Falls, N. Y.; G. D. Piper, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., and A. O. Backert, Cleveland. To the vacancy caused by the death of B. J. Walker, of the Erie Malleable Iron Co., Erie, Pa., H. J. Koch, of the Fort Pitt Steel Casting Co., McKeesport, Pa., was appointed. For the valuable assistance rendered by Mr. Koch your committee wishes to make special acknowledgment.

BENJ. D. FULLER, Chairman,
Westinghouse Electric & Mfg. Co., Cleveland.

H. J. KOCH,
HARRINGTON EMERSON,
E. G. FELTHAUSEN,
H. O. LANGE,
Members.

Report of A. F. A. Committee on Uniform Costs

In presenting this report your committee assumed that practically every casting manufacturer has a cost system of some kind. These systems vary as widely as the number of cost experts or accountants by whom they are installed and due to this lack of uniformity in systems, theories or bases from which they arrive at the costs, the chaotic condition maintaining in the foundry industry today is attributable. It is evident, therefore, that the essential feature in the elimination of existing conditions is the adoption of a uniform basis or theory which should underlie all cost systems for the computation of foundry operations.

In other words, your committee does not recommend the adoption of a cost system, but the adoption of a uniform basis of figuring costs.

The factors or theories constituting this uniform basis follow:

1.—A commodity sold by a foundry is the labor of the molder and coremaker and not the material entering into the product.

2.—The material is more or less of a constant, varying with market conditions.

3.—Cost of production fluctuates in proportion to pounds of output per molder.

4.—Overhead charges increase or decrease according to pounds of output per molder.

Discussing factor No. 1: What is the merchandise or commodity sold by a foundry? In the last analysis, is it not the product or the labor of one, 10 or 100 molders? Is it not what they really produce and not what the furnace produces?

Referring to factor No. 2, material is subdivided into two classes:

a.—Material such as pig iron, scrap, coke, gas, etc., directly chargeable to melting.

b.—Sand, flour, molasses, emery wheels, core binders, nails,

chaplets, etc., are chargeable to other departments as a direct expense.

Factor No. 3 is controlled by slow-moving and rapid-moving jobs. These phrases have been coined to differentiate between small tonnage per molder and large tonnage per molder.

Factor No. 4 is not a constant, but is a variable paralleling No. 3, overhead charges increasing with slow-moving jobs and decreasing with fast-moving jobs.

Harmonizing Various Methods

It is with a view of harmonizing the various methods employed by American foundries to secure more uniform, as well as more accurate results in these plants and to insure higher efficiency that this committee has agreed upon and submits for your consideration principles which, in its opinion, should be made the basis of a cost system to be adopted generally by American casting manufacturers.

It is evident that competing foundries in the same locality pay approximately the same price for

a.—Material.
b.—Labor.
c.—Same production (depending upon management and equipment).
d.—Same sales and clerical (nearly).
e.—Same rent, interest, taxes, insurance (approximately).
f.—But they do not follow the same method of computing or grouping the foregoing.

It is not difficult to ascertain accurately the total monthly and annual costs of

a.—Metals.
b.—Materials.
c.—Labor.
d.—Expenses (or commonly referred to as overhead charges).

It follows then that four fundamental requirements must be considered:

a.—Accurate payroll distribution.
b.—Accurate stores (material disbursements, covering only the month's actual consumption—not receipts).
c.—Accurate bookkeeping.
d.—Production in net tons of good castings to ascertain

the proper divisor for all amounts obtained from the foregoing.

The problem of greatest difficulty is to find the proper differential of overhead costs, or rather the proper method of distributing the overhead to the various departments and patterns. It will be conceded that a different overhead is to be applied to almost each and every job and briefly stated, a fast-moving job should not bear as great an overhead as one that is slow-moving.

What is the standard basis or key for such different jobs? This has proven a stumbling block to many foundrymen and accountants, as it is difficult to get them in agreement on this point.

Many ways in which the overhead charges are figured might be mentioned, but your committee wishes to emphasize that it is endeavoring to recommend a system which first will appeal to the manager, superintendent or foreman, realizing that the expert accountant may criticize this recommendation in not having carried it out in further detail. To obtain the hearty co-operation of all of the heads of the departments to insure the satisfactory operation of a cost system, it should be simple and not too greatly involved. Your committee has endeavored to find not necessarily the most perfect system, but the simplest one which can be applied most easily by the greatest number of foundrymen. Therefore, it has been decided to recommend what might be termed "the-tonnage-per-day-per-man-plan".

Tonnage-Per-Day-Per-Man-Plan

In recommending this plan it is realized that many will take issue with it, but in doing so the committee is striving only for a point from which to start. Some may inquire about weight and while this point is acknowledged as well taken, it is not advisable to become too scientific at the beginning, as the plan can be further refined. What is required is a simple theory to begin with, one that any manager, superintendent, foreman or molder can comprehend fully and not one that is merely understandable by an expert and an accountant. One reason for adopting what might be termed

"the-tonnage-per-man-plan" is that almost every foundry can turn to its past records for a year or several years and establish an average per day per man that has been molded for this period. Also, the number of molders' hours for a similar period can be ascertained. Then ascertain if the average man produces 100, 500, 1,000 pounds per day, or whatever amount this may be, and the standard of the plant thus is secured to start with. It will not be difficult to obtain the total amount of expenses or overhead charges for the same period as covered by the tonnage per man, as almost any system of bookkeeping will show this. Divide this total by the total tonnage produced during this same period and the average overhead expense per ton or per pound, as well as the average production per molder, will thus be obtained.

The overhead is based entirely on the labor of the molder and coremaker, eliminating cleaning room labor, etc., which might be included, but which will not be taken into consideration at this time as cleaning costs, etc., will be taken care of subsequently.

Variable Distribution of Overhead

It will be assumed that two standards have been obtained, namely, the tonnage or pounds per man and the overhead per pound. Suppose that the tonnage per molder per day, or the average output per day per man, is 500 pounds and that the overhead expense per ton is $10, or ½ cent per pound. If the job is of the average molding type, one which can be produced at the average of 500 pounds, the average cost applies. If, on the other hand, the job is light weight, difficult or slow to mold and only 250 pounds is obtained per day, the overhead would be about twice as much as when the output was 500 pounds, or the equivalent of $20 per ton, or 1 cent per pound in place of the standard or average of ½ cent per pound. It then is necessary to add to the average cost not only the cost of extra molding, but the ½ cent additional overhead cost. It is apparent that if the foundry is operated on this slow-moving class of work entirely, the yearly tonnage would be about one-half of the average. The expenses would be about the same and, therefore, the costs for conducting the business

would be twice as much per ton as on average jobs. Unfortunately, most foundrymen fail to add the ½ cent increase for overhead, although they may be laboring under the delusion that they are adding it under the extra cost of molding .

Let us consider another job in which the reverse condition applies. This can be molded at the rate of 1,000 pounds per day per man and the tonnage produced, therefore, will be twice the average of 500 pounds. The overhead expense per ton then will decline about one-half; let us assume that it is 50 per cent. From the average cost should be deducted the amount saved in molding and also one-half of the overhead cost, or $5 per ton. The amount chargeable for overhead will then be ¼ cent per pound in place of the standard ½ cent per pound. On this class of work the tonnage per year would be double and with the overhead expenses practically constant, it is apparent that the overhead per ton would be only one-half of the previous average overhead. In competing for business the foundryman who does not take into consideration the variables cited will not get the order and only too frequently complains that his competitor did not know his costs and obtained the work at ruinous prices. It follows then that the foundryman, without an adequate cost system, readily secures all the difficult work on which no profit can be realized, as his price is liable to be lower than his competitor on this class of work, whereas he is not favored with the better class of work or the rapid-moving jobs owing to his failure to consider the variable overhead. This condition will prevail regardless of the fact that this foundryman may be able to produce castings as economically as his competitor.

Variable and Constant Overhead

To define more clearly the results obtained by figuring on a variable overhead and a constant overhead, we will cite the following examples: It will be assumed that the overhead cost per molder, or floor, is $2.00 per day. Two jobs are accepted; on the one the output is 200 pounds per day and the other, 1,000 pounds per day. It will be assumed that on both jobs the molder receives $3.50 per day. The following

roughly illustrates the method of estimating or calculating the costs recommended:

	Production per day, per man, 200 lbs.	Production per day, per man, 1,000 lbs.
Direct cost (molder one day at $3.50).....	$3.50	$3.50
Other constant costs at 85 cents per cwt....	1.70	8.50
Assumed average overhead per molder or floor	2.00	2.00
Total cost.....	$7.20	$14.00
Actual cost per pound.....	0.036	0.014

If these two tasks had been figured in the old manner of distributing costs, except direct cost for molding, we would obtain the following results:

Castings, weight.	pounds. 200	pounds. 1,000
Direct cost	$3.50	$ 3.50
Average constant cost, assumed average overhead cost per pound at 1.183.....	2.37	11.83
Total cost	$5.87	$15.33
Assumed cost per pound.....	0.0293	0.0153

It will be noted, therefore, that by the recommended method of figuring the cost of 200 pounds of castings it would be 3.6 cents per pound, as compared with only 2.93 cents per pound by the old method. In other words, the slow-moving job, by the old method of figuring, would take a lower price than the slow-moving job by this method of estimating. On the contrary, the fast-moving job, involving 1,000 pounds of castings, would be charged for at a higher rate by the old method than by this plan, namely, 1.53 cents per pound, as compared with 1.4 cents per pound.

Increase Cost of Slow-Moving Jobs

The effect of the proposed system is to load a higher cost on slow-moving jobs. It is believed that foundrymen generally have appreciated the necessity for this since it is evident that a shop which is compelled to operate on slow jobs does not turn out as many, nor does it get the returns that it would on

jobs permitting a higher tonnage. It is not claimed for the foregoing system that it will prove to be 100 per cent efficient, but in most instances it will be above 75 per cent accurate, and in some lines this may exceed 90 per cent.

This report would not be complete without incorporating a recommendation for the adoption of a general form for ascertaining the annual or monthly operating cost, including the totals of the three following fundamentals:

a.—Metals consumed.
b.—Material consumed.
c.—Labor and salaries.

These items can be subdivided and distributed over the different foundry departments, this distribution being shown on the accompanying form and is as follows:

1.—Melting department.
2.—Molding and core department.
3.—Cleaning department.
a.—The total of these gives the producing total of metals, material and labor.
4.—Pattern department.
5.—Flask department.
6.—Power, light and heat.
7.—Repairs and maintenance.
8.—Yard.
b.—The total of the foregoing shows the entire manufacturing cost.
9.—Rent account, including insurance, taxes, obsolescence or depreciation, and interest on plant account.
10.—Administrative or executive expense, including balance of interest, salaries, stationery, telephone, postage, etc.
11.—Sales department.
12.—Extraordinary charges.
c.—The total gives the general cost.
13.—Castings returned from customers.
d.—Grand total of the entire cost. The item of total dollars expended should check with the ledger.

This will give the general average cost for the tonnage produced and can be used as the cost standard if the principal differentials are added or subtracted. It also can be employed in the nature of a check on the results of each foreman from month to month or what is termed "the control or comparative cost". In the foregoing subdivisions is included the item of

extraordinary charges. This is separately indicated to eliminate from the preceding departments any unusual charges which would not be constant and would otherwise affect the control cost or prove to be unreasonable charges against a certain department for the month.

Voucher System Recommended

To obtain this result the use of a voucher system is recommended. It also is essential to have an accurate payroll distribution for each department, and it is necessary to make a detailed distribution and accounting of all materials used. It is necessary to ascertain the accurate tonnage produced by weighing the castings or estimating such castings as cannot be weighed in bulk in the cleaning room on the first of each month, or any other period decided upon, and to add the increase or subtract the decrease from the month's shipments. The amount produced is used as the divisor of the amount charged to each department and also the total value charged to all departments, according to the amounts shown by the voucher record or ledger. If this production divisor is not correct, it throws out the cost for the month and the succeeding month.

The accompanying chart is compiled on an assumed production of 500 tons per month and it will be noted that it records the amounts charged to each department and the cost per ton of material and labor and the total cost per ton for each department. While the foregoing gives the average of one month only, it is necessary to obtain averages covering periods of one, two or as many years as desired to obtain an average that will cover a period of trade depression and periods of prosperity. In the compilation of these averages practical knowledge and common sense should be employed. Remember that the metal is not the only merchandise sold and shipped. While the metal cost is fairly constant, it fluctuates somewhat as the result of the remelting of scrap, including heads, gates, risers, etc. In explaining the methods by which the average is obtained the figures on the accompanying chart will be referred to. It is essential to ascertain the average remelt,

especially that of heads and gates, so that if an order takes a large head the proper differential should be added to the standard average cost of $65.30.

Variations in Shipment and Melt

At this point it might be advisable to direct attention to the wide fluctuation in the percentage of castings shipped and the total melt in various shops and for different classes of work. This variation, while being greatest in steel casting work, also is

Production 500 Tons									
	Metal		Materials		Labor		Total	
	Total	Per Ton	Total	Per Ton	Total	Per Ton	Total	Per Ton
1. Melting	$850.00	$1.70	$1000.00	$2.00	$1300.00	$2.60	$1080.00	$2.160
2. Molding and Cores			1375.00	2.75	(Direct 500.00 Ind. 250.00 Prof. 400.00)	1.00 3.00 8.00	687.500	1.375
3. Cleaning			100.00	.20			500.00	1.00
Manufacturing Overheads: 4. Producing Total	850.00	1.70	3375.00	6.75	1280.00	2.560	2467.500	4.935
5. Pattern			150.00	.30	225.00	.45	375.00	.75
6. Flasks			275.00	.55	100.00	.20	375.00	.75
7. Power, Light, Heat			350.00	1.40	250.00	.50	800.00	1.60
8. Repairs, Maintenance			265.00	.53	400.00	.80	665.00	1.33
9. Yard			250.00	.05	400.00	.80	425.00	.85
10. Manufacturing Total	850.00	1.70	4665.00	9.33	1415.00	2.830	2731.500	5.463
Executive Overheads: 11. Rent Account			600.00	1.20			600.00	1.20
12. Administration			1000.00	2.00	205.00	.410	305.000	.610
13. Sales			100.00	.20	325.00	.65	425.00	.85
Other Overheads: 14. Extraordinary Charges			400.00	.80	600.00	1.20	1000.00	2.00
15. Total Cost	$850.00	$1.70	$6740.00	$13.48	$1715.00	$3.430	$3290.00	$6.478
16. Returned Castings							260.00	.52
17. Grand Total							$3265.00	$6530

FORM FOR ASCERTAINING ANNUAL OR MONTHLY OPERATING COST

a factor of importance in iron foundry practice. One large manufacturer operates two iron foundries, one on light and the other on heavy work. The output of the light foundry averages 5 pounds per casting, while the output of the heavy work shop averages 125 pounds. The proportion of shipments to melt of the light shop is 55 per cent, while that of the heavy shop is 70 per cent.

After having obtained the total average cost of $65.30, subtract the amount of direct or productive molders' and coremakers' labor, which is $10, leaving a total of $55.30. After ascertaining the direct or producing molding and core

labor per ton for a job which is not exactly the average, namely $10 per ton, add to this the sum of $55.30. In other words, $55.30 is the starting point for all costs and possibly might be termed "zero labor" or the cost of castings exclusive of the molding expense.

Since the cleaning cost was not included in the direct or productive labor on which the overhead was based, it will be taken care of as follows: According to the accompanying chart the average cleaning cost is $8. If the casting is difficult to clean, the cost will exceed this amount and if it is below the average in cleaning expense, it will be less than the average of $8. This difference should be added to or subtracted from the average cost of $55.30. It is not difficult to ascertain for any casting whether it is more or less expensive than the average pattern to remove the heads and gates, or to judge whether it takes more or less grinding, chipping, etc., than the average. Large heads, excessive core work, etc., as a rule, mean high cleaning costs. From experience one can readily determine whether the cost should be increased or decreased as a result of abnormal or subnormal cleaning of any design.

Next, ascertain the average of the defective castings made in the foundry. Then add to or subtract from $55.30 an amount covering these defectives which may be estimated, or is shown by the records as applying to the particular pattern in question.

It may be approximately assumed that items Nos. 4 to 11 on the accompanying chart make up the overhead expenses. The cost per ton will vary more or less with the production, but the total amount charged against these departments will remain fairly constant. Therefore, the average overhead per ton is readily obtained and is shown to be $15.43, or approximately ¾ cent per pound.

Examples for Application of First Theory

To apply the first theory referred to, the following examples are cited:

If the job is strictly of an average type costing $10 for direct molding and core labor, the total cost will be $65.30.

If the job is slow-moving, add to the standard average cost of $55.30 the proper amount of overhead. If the castings cost $20 for direct molding and core labor, which is double the average of $10, they carry $30 overhead, or twice the average of $15, which results in $55.30 plus $20 molding and core labor, plus $15 extra overhead, and equals $90.30.

If rapid-moving, and the castings cost only $5 for direct molding and core labor, they carry an overhead of only $7.50, or one-half of the $15 average. Therefore, to the $55.30 standard average cost we add $5 for molding and core labor, which equals $60.30 and from which we subtract $7.50 for reduced overhead, and we arrive at a total cost of $52.80.

In this connection, it is interesting to direct attention to the wide fluctuations in the cost of fast and slow-moving as compared with the average job. The average job in this case is represented by $65.30; the fast-moving job at $52.80 and the slow-moving job at $90.30.

The proper variations can be figured for every $1 per ton above or below the average molding and core labor cost of $10. For all practical purposes a variation of $2.50 per ton, or ⅛ cent per pound, will be sufficient. The result of the cost obtained on any particular pattern will not vary widely from that secured by a more elaborate system which is difficult to understand and frequently so burdensome that it will not receive the hearty co-operation and support of the heads of the operating department.

Instructions for Obtaining Proper Cost

From the foregoing examples the following simple instructions will aid in arriving at the proper costs. On the accompanying chart the grand total is given as $65.30.

Add or subtract for heads and gates above or below the average or standard.

Add or subtract the difference between the specific and the standard direct molding and core labor cost.

Add or subtract the difference between the specific and the standard or average cleaning cost.

Add or subtract the difference between the specific and the standard, or average defectives.

Add or subtract the proper differential of overhead costs.

Add contingencies, extra flasks, pattern changes, etc.

By following these instructions the total cost of a casting of any pattern can be obtained.

Most foundries do not hesitate to pay good salaries to the heads of their various operating departments, but they hesitate at a proportionate outlay for an intelligent accountant, estimator or clerk, however he may be designated. It also is unfortunate that foundrymen only boast of tonnage records and rarely refer to their best months by profits regardless of the tonnage produced.

In carrying out this system, it is by no means necessary to obtain costs on all small orders, job lots, etc. However, large orders can easily be estimated, followed through the shop and checked and can be properly priced as a basis for an estimate for the next inquiry.

This record of any past production also will give the number of castings made per day.

Another feature of this method is that today it can be applied on any order made months ago, provided the number of castings molded per day, as well as the weight of such castings, has been recorded.

It is not necessary to tabulate the cost of every order, which will save considerable detail work, but the cost today, tomorrow or a year hence can be obtained if the records are filed indicating the output of each molder per day on the various patterns. In conclusion, it will be noted that the percentage theory has not been used for figuring the overhead, but rather the amount in dollars and cents, in the belief that this can be followed more satisfactorily by the heads of the operating departments without losing the support of the accountant.

In line with the foregoing theory, the profit should be figured in dollars per ton. Let it be assumed that the justified profit is $2 on an average tonnage per month of 100, or a total of $200. If the work going through the shop is slow-moving, notwithstanding the fact that every molder is employed when only 50 tons are produced the profit should be $4 per ton, which equals the average of $200 per month. If, on the

other hand, the work going through the shop is of the rapid-moving variety, so that the same number of molders produce twice the output of 200 tons, the profit could be reduced to $1 and yet make the average of $200 per month. The results by this method of computation are the same regardless of the class of work taken by the sales department.

Recommendations

To promote the adoption of a uniform method of keeping costs among the members of the American Foundrymen's Association and the foundry industry at large, the employment of a cost accountant is recommended who is in thorough harmony and sympathy with the methods outlined. Ways and means for meeting this expenditure is the subject for the consideration of your executive committee, but as a suggestion, it is recommended that 100 foundrymen guarantee a fund by the payment of $50 each, or 50 foundrymen guarantee to pay $100 each during a period of one year. Each of these foundrymen then would have first call on the services of this cost expert and during the year he could remain at each of their plants a sufficient time to teach the accountants the basis or theory of the system recommended. Also, general meetings could be held in the various localities which the cost accountant visits and the system further explained so that more foundry competitors would be interested in the adoption of the uniform cost theory. In making these suggestions it is realized, of course, that the association has not sufficient funds to defray the cost of an expert's services, nor would it be fair to the membership at large to employ such an expert for the benefit of the comparatively few whose plants he could visit within a year. Therefore, the plan has been devised of underwriting a fund to defray the cost of the expert's services and his expenses.

Discussion—Uniform Costs

THE CHAIRMAN, MR. R. A. BULL:—I feel that we have here a most interesting report, gentlemen, and a particularly pertinent conclusion and suggestion, and would be very glad to have some discussion on the matter.

MR. O. V. CHAMBERLIN:—I would like to have a definition of the difference between slow-moving and rapid-working work. Does that refer to just work in the foundry, or is that also governed by the delay previous to shipment of the material?

MR. H. J. KOCH:—I will answer that it depends on the foundry whether the molder produces 500 pounds per day or 1,000; overhead is based entirely on the production of the molder.

MR. O. V. CHAMBERLIN:—It has nothing to do with delayed shipment or anything of that sort?

MR. H. J. KOCH:—No, sir.

MR. H. M. RAMP:—Did the Committee consider the question of figuring the molding cost instead of going on this percentage basis of 500 pounds? When you have 500 pounds you are going to charge 50 per cent, etc.; why wouldn't it be a good plan to figure out a molding burden, coremaking burden and a cupola burden? The reason I mentioned this is that we have tried it and find that it is the most accurate way to figure a burden. Our experience has been very satisfactory with it.

MR. H. J. KOCH:—You arrive at practically the same result, your idea of getting at the burden is somewhat the same as the committee's idea. You could take this $10 spoken of here; the only reason that was used instead of time was that it seemed more simple and a short cut; or you might take floor space, which is even better. If you go up with your overhead proportionately to the slow-moving or decreased tonnage, you get the same thing the committee is after.

MR. H. M. RAMP:—I thought it would be simpler to understand.

MR. H. J. KOCH:—Wait a minute; that may be more simple for you and maybe for some others, but if you have reviewed this, the way the committee has, you will find that the man we are after is the man who has no cost system at the present time. We evidently are not after you. We might want your support. I don't think there is anything in here that would take your support away from us, but we are after your competitor who does not figure cost at all. If I understand your question rightly, you would arrive at practically the same thing. You can take the same system and divide up your floors, as one illustration is here, and assign say, $2 to each floor; whenever you use less floor, your overhead goes up with it or you can take it by the hour the same way. I did not quite understand your burden on the cupola, but that is immaterial.

MR. H. M. RAMP:—You can add that to the other, if you want to.

MR. B. D. FULLER:—The committee feels that there is a great necessity for a uniform method of figuring costs among foundrymen. It has been evident from what has been accomplished by the stove and valve men and also in other lines, that there is a great benefit in it, and their experience shows the need of it. If you could have looked over the correspondence in answer to Mr. Backert's inquiries, you would realize what I am trying to tell you. One man answered that in figuring his selling price he used the very best judgment he had himself, and he said "sometimes from the results I obtained, I don't think my judgment is worth a damn." Now that is an answer to one of the questions, but the overhead varied, from 25 per cent to 35 per cent, and it is the hit and miss, Tom, Dick and Harry way of doing things that we are trying to get at. I am sure that the Association could not do a better work than get this thing started.

MR. H. J. KOCH:—The Association would employ this cost accountant; he would come to your works and he would dovetail the two together to your satisfaction. I think you get the idea that the underlying point in this paper is to put an end to ruinous competition.

MR. H. E. FIELD:—I think that the committee has got up to a point where something ought to be done. I think the recommendation of getting these subscriptions is a mighty good one, and some action ought to be taken at some meeting by which this system can be put into effect. I think this system embodies, in a simple way, the best practice in the average foundry. I know several friends of mine, including Mr. H. D. Miles, of Buffalo, who spent about a year of his good time trying to get the gray iron foundries to be sane and sensible instead of going out and taking a casting, with the statement, "Well, if the other fellow can make it for that, I can't loose much on it, I will take it for half a cent a pound less;" but he gave it up as a bad job. This report evidently has taken the time of some men whose time is worth a great deal, and has been given gratis to the Association. If it was worth giving this work to these men to do, it is worth while for the Association to take some action on it and not let it go into the discard the same way some other things have been discarded in the last seven or eight years.

THE CHAIRMAN:—I think that Mr. Field's suggestion is very pertinent. It is time that the Association should get down to brass tacks on this question, and it would be entirely proper for a motion to be introduced to that end. I do not want to suggest a motion now, however, if any further discussion is desired.

MR. H. M. RAMP:—We started out to find out how much certain castings were costing and when we got through, we found that we were paying the other fellows a little for the privilege of making them. We raised the prices and they went somewhere else. We found out, by going into it, that we were paying others for the privilege of making their castings.

MR. H. J. KOCH:—You may do a smaller tonnage business, but you will make more profit.

MR. H. M. RAMP:—Yes, we cut our tonnage down, but helped our profits.

THE CHAIRMAN:—Mr. Stephenson is present and would naturally have some ideas on this subject. We would be pleased to hear from him.

MR. F. J. STEPHENSON:—I don't know that I have anything to add to what has been said, more than this: it was my privilege to meet with the Cost Committee and I heartily coincide with their views on the subject. I would only say this, that, though there are those among you who want more refinement than others, I am thoroughly satisfied that the fundamental principles that are laid down in this report can be amplified and you can get all the refinement that you want. I don't care how closely you want to go into it, whether you are making 1,000-ton castings along side of a two-pound casting, whether you want to know the entire cost of operating cranes, or one thing or another on a certain style of casting, there is absolutely nothing in this formula which will prevent you from obtaining the information; it can be amplified to meet the requirements of the most painstaking man and it is simple enough for the foundry foreman, the molder or the manager of the smallest plant. I do know, from actual experience, that work of this kind can be carried out successfully, and it is being carried out in many associations. It has been successful in associations which I have the honor to represent and I believe that you will earn a great profit from any effort that you may make along this line.

MR. H. J. KOCH:—I would like to announce that this report had the unanimous approval of all the members of the committee, and the same idea and theory has been worked out in at least three of the plants of the members on the committee. When the members of the committee got together, they found out that their ideas were just the same except as to some of the refinements Mr. Stephenson speaks of. Mr. Fuller's company goes a little bit further than our company and some others. They don't sell the castings as we have to sell them. We have to name a quick, ready price over the telephone; they can get their costs after the castings are made. Mr. Stephenson says, you can carry this theory out and get it down to a fraction of a dollar, down to a few cents, or can be within perhaps one or two dollars of the cost on everything, but you do not have to use it on every order of odds and ends that comes into your plant.

MR. A. O. BACKERT:—We have a written contribution to this discussion from Mr. C. B. Segner, of the Domestic Engine & Pump Co., Shippensburg, Pa. Mr. Segner's letter follows:

Our foundry foreman, Mr. Fackler, who is a member of your Association, has handed the writer a copy of the reprint of the report of your Cost Committee. I have read over the report with great interest and profit and heartily agree with the majority of the recommendations submitted, but noticing that the recommendation for method of distribution of overhead expense is one we discarded some time ago, I thought that your committee would be interested in the reasons for the same and I am, therefore, taking the liberty of writing this letter for their attention.

Our firm maintains a foundry for the production of our own castings, doing little outside or jobbing work; at the same time, we are anxious that our costs of castings be correctly estimated on the same basis as though we were making them for sale to other manufacturers. We formerly used practically the method of distributing overhead that you recommend in your report, but about 1½ years ago we discarded this method in favor of what you term "the old method."

Our opinion, based upon observation in our own foundry is, that the overhead expense bears a closer relation to the tonnage produced than to the number of hours worked by the molders; for instance, we will suppose that a man is working on a snap bench and is producing 500 pounds of castings per day; this same man is then put to work on a molding machine and for the same amount of wages he puts up 1,500 pounds of the same kind of work per day. To do this, he requires three times the floor space, three times the amount of sand, facing, etc., it requires three times as much labor to clean the castings and the interest, depreciation and up-keep of the molding machine must be absorbed by the overhead expense; therefore, it is evident that in a case of this kind your proposed method of charging the floor with a certain rate per day, regardless of the amount of work produced, would be entirely unfair.

It is true, of course, that work that is naturally slow moving should be charged a higher overhead expense than fast-moving work, but I do not believe that this can be properly proportioned by basing it upon the amount of time required by the molder. We try to take care of this by dividing our castings into two classes:

Class *A* is the more difficult work, usually requiring considerable cores.

Class *B* is the plainer work, with little or no cores.

All the overhead expense connected with running the foundry, aside from cupola expense, is charged against the good castings produced at a certain price per pound; this price is higher for the class *A* castings than for class *B*. At the present time this amount is $1.10 per 100 pounds for class *A* castings, and 96 cents per 100 pounds for class *B* castings.

These figures are based upon our judgment of the relative amount required for cleaning the castings and the amount of sand and other expense materials that are used for our work. Each job that is completed is charged with its proportion of overhead expense according to the foregoing figures, and at the end of the month a balance is taken to see how near the amounts charged against production tally with the actual expense plus fixed charges, and the charge for the next month is adjusted to correct any shortage or excess that might occur.

We do not claim that our method is absolutely accurate; in fact, it is impractical to obtain close accuracy by any simple method, but we do believe that our method gives us closer results than the method we formerly used and which your committee has recommended in this report.

I shall, however, follow the discussion closely and shall be glad to know the arguments that are advanced for and against this method.

MR. A. O. BACKERT:—Now I believe that letter is a good deal like two or three hundred other letters that we receive from time to time in this cost investigation, and as Mr. Field pointed out, this Association, half a dozen times in the past, started to revise foundry cost systems and to adopt standards, etc., and the only adopting that was done was adopting them in the *Transactions*. They have been buried. Now, in order to get anywhere, there must be co-operation among the foundrymen and as nothing can be done without money, a fund must be raised to employ a cost expert. I believe that every foundryman here has got some cost system; in fact, I have never met one that did not. They all feel that their cost system is the best thing in the world. You know "Bill Jones" across the street has no cost system, because every time a nice, juicy order comes along that you think you ought to make some money on, "Bill" gets it and you don't. You can either contribute $50 or $100 according to these recommendations, and I believe it is the best investment any foundryman can make, to contribute $100 to this Cost Committee to defray the expense

of installing this system in your competitor's foundry; you don't need it, but get it in there, he is the boy you want to help. If you find that you don't need this cost system, help out the other fellow. Maybe you have got half a dozen competitors right in your vicinity; it will give you a good opportunity to spend $600 or $700 right there, and I move that a committee be appointed to carry out the recommendations made in this paper. I believe that it ultimately must be passed upon by the executive board, but I do believe that a committee, acting through the secretary and in correspondence with the members of the American Foundrymen's Association, can put a plan into effect that will carry out practically what we have hoped for theoretically so many years in the past.

THE CHAIRMAN:—As I understand your motion, Mr. Backert, it is to the effect that a committee be appointed which shall, in conjunction with the secretary, correspond with the members looking to the adoption of the recommendations made by the committee?

MR. A. O. BACKERT:—Yes sir.

The motion was seconded and adopted.

THE CHAIRMAN:—I think that is a very important step and I am glad to see it taken. Does Mr. Fuller or Mr. Koch wish to verbally reply to the criticisms?

MR. H. J. KOCH:—I would like to reply to this letter. It states that one man in a month will turn out 75 tons and another, 225 tons; let us assume that his salary is $75 per month; therefore, in the case of the slow moving job, 75 tons, he costs his company $1 per ton overhead. In the case of the other, or the fast moving job, for which he gets the 1,500 pounds per day per man, his salary at $75 per month would cost only 30 cents per ton.

MR. B. D. FULLER:—I would say that according to that letter he is apparently using the method of applying his overhead to weight. The company I am working for has used that method for years and it has established, without a shadow of a doubt, that it is not right, and we have, within the last year, reversed ourselves and are using a different method. All along it has been the cause of a great deal of soreness among the dif-

ferent department heads of our company. One fellow who was making the big castings, was howling that it was costing too much, while the fellow making the little trinkets that go out by the thousands had not been saying a word; he has been happy. Now things are reversed, we are getting the howl the other way and making them pay what they should for their castings, and that method of applying the overhead to weight is no good.

MR. B. L. GRAY:—I would like to ask the members of the Committee one question; in a little foundry in which I am interested it is the practice to estimate the cost from the amount paid the molder. One does not get it in detail from each job, but from different ones at the end of the month one can arrive at the method, and I would like to ask the opinion of the members on that.

MR. H. J. KOCH:—I didn't understand you.

MR. B. L. GRAY:—Our conclusions are arrived at on the basis of the dollars paid molders and everything is constructed from that point. Of course, at the end of the month we can get our tonnage from different firms or for the different firms, and arrive at conclusions from that, and based on a period of several years, we get some idea of our standing at the end of each month. I would like to ask your opinion of that.

MR. H. J. KOCH:—We simply used $10 instead of your $1; took that at half a cent a pound as being more easily followed than some other amount.

MR. C. A. JOHNSON:—May I ask the previous speaker what was included in his overhead, whether he has taken any material of his foundry into his overhead that he does not throw on weight? He says he has thrown the most of his overhead not on the weight, as heretofore. May I ask what his company generally treats as overhead, if any of the materials?

MR. B. D. FULLER:—Yes, that is a refinement of this system. As a matter of fact, the system adopted by the company does not place all the overhead directly on labor. There is, as I mentioned in reading the paper, a sub-division where part of

it goes to weight. That is a refinement we did not want to dwell upon, in order not to draw this thing out, but there are accounts where it is recognized that weight should carry certain portions of the overhead. I could not tell you off-hand the exact sub-divisions for all the different things, but there is some material and labor carried by weight, that is, a certain proportion, the larger proportion on labor and a certain proportion on weight.

Scientific Management and its Relation to the Foundry Industry

By H. K. Hathaway, Philadelphia

In spite of the wide publicity that the scientific management movement has received, there is so much misunderstanding as to what scientific management really is, what its advocates aim to accomplish through its application, and how it is applied, that a brief explanation on each of these points is necessary in order that the plan I propose may have a proper background.

Scientific management must not be considered merely as a means of securing greater dividends for the stockholders, but rather as a means to the general betterment of human welfare. It is true that under present social and economic conditions, as Frederick W. Taylor said in a statement that has been misapplied by his opponents, "the chief object of any company must be the earning of profits for its owners". It is self-evident that unless this object is accomplished, sooner or later the company must fail. This is one of the objects of scientific management, but not the only one, nor was it regarded by Mr. Taylor as the greatest.

Did scientific management accomplish no more than this it would be a failure, but without doing so it could not, under the existing economic system, accomplish those bigger objects upon which the earning of profits are in turn dependent.

Broadly speaking, scientific management is intended to produce more wealth for a given expenditure of effort, as a result of elimination of waste in the matter of time, work and materials.

Mr. Taylor in his lectures was wont to emphasize the fact that wealth in usable form only comes into existence through the efforts of those who are to enjoy it. The producer and

the consumer, broadly speaking, are the same person, and by consequence any increase in production of useful articles cannot help but benefit the producer.

A French Scientist's Version

In his preface to the French edition of Mr. Taylor's book, "The Principles of Scientific Management", Mr. Henri Le Chatelier, the famous scientist, says:

Let us suppose for an instant that the belief in economic determinism has become general, and let us endeavor to unravel some of its laws. Here, for example, is the first one, extremely simple, too evident even, you will say, to be worthy even of mention:

> *In civilized countries men have a great desire for enjoyment, seeking all of the pleasures of life and being disposed to put forth considerable effort in order to procure them:*

Restraint in civilized lands in indispensable. Often the negroes of the African tribes content themselves with the most rudimentary habitations, go without clothing, and have as their sole ambition to lead a vegetative life basking idly in the sunshine. Such countries have their own peculiar economic conditions.

On the contrary, in civilized countries, the desire to enjoy the pleasures of life, each day more numerous, to possess worldly goods in greater number, to gain more money because in exchange for money may be procured all of the enjoyments sought, is certainly the most powerful motive capable of producing activity among mankind. One is stupefied to see the amount of work that the small farmer or the workman who owns his own house will do when he is certain of not having to divide the fruits of his labor with anyone. In that lies a certain truth, an economic law. In spite of its simplicity and its self-evidence, it is not out of place to mention it in consideration of the consequences that it entails.

Here is one of these consequences which constitutes itself a second law, no less certain than the first, but yet less generally accepted. Its importance is enormous from the workman's standpoint:

> *The inhabitants of any civilized country become twice as rich each time that they succeed in doubling*

their production because they have then each one on the average two times the things, useful or agreeable, to consume.

This truth, this law, is again so evident that there should be no need of justifying it. In a country where each inhabitant produced everything to satisfy his needs no proof would be possible; this law then would apply equally well to savage tribes as to civilized peoples. It was formerly thus in France; the peasant produced on his land the wheat necessary for his food; he next ground it and made it himself into bread. He raised also a pig which he killed and salted for his winter provisions; he cultivated flax from which he spun and wove his cloth; he hewed also the wood of which he built his house and grew the straw with which he thatched it. In increasing his production as is made possible today by the employment of agricultural machinery he has obtained a much higher return from his labor. The sale of this surplus of his production has made it possible for him to replace the hut of his fathers by a solid house of stone roofed with slate instead of straw. His installation in this luxurious abode will remain for him the greatest joy of existence and lighten all his troubles.

If our farmers and our textile workers succeed today in producing together by grace of this specialization twice the quantity of useful articles as in the past they will each be able to procure, whether directly or by exchange twice as much as formerly, and they shall therefore have become twice as rich as formerly.

There is, however, a reservation to be made here; it does not suffice in the case of specialization, that one isolated individual should double his production in order that he may become twice as rich; it is still necessary that his neighbors should do as much, otherwise he would have no one with whom to exchange the products of his labor, which would then do him no good. There is in that an essential condition of the law of proportion between the increase of production and that of riches.

One often hears it said that increased production is not necessarily followed by increased consumption, that it is necessary to avoid exceeding the power of absorption of the consumer. In reality there is no limit to this power of absorption, at least in civilized lands, because neither is there a limit to the desire of well-being. This is a truth that it is necessary to proclaim incessantly and which everybody should be made to see.

So long as this truth is not recognized, the ideas advanced by Mr. Taylor will not be appreciated at their just valuation because their one object is to increase the productive power of every man. Machinery, although employed too often without method, has already produced enormous results in this direction. Within a century the production per man has been increased about ten-fold through this agency, and in consequence mankind is ten times richer. The methods proposed by Mr. Taylor make it possible, without any change in present machinery, to double again and in some cases to triple the production of each workman and consequently to double and triple wealth generally. How does it happen that a law so useful and so important, which should be well-known, should be so generally unrecognized and contested? The explanation must be looked for in the multiplicity of errors of human judgment. Instead of relying upon simple common sense, people are prone to enter into long calculations that are completely wrong, or on the other hand let themselves be guided by unreasoning sentiment.

This essay of Mr. Le Chatelier's is the clearest and best exposition of the economic importance of the scientific management movement, and one which ought to be read by all workmen and all employers.

Scientific Management Inevitable

Scientific management seems to be inevitable. Labor is contantly demanding a larger portion of the wealth produced; the standards of living of the great mass of the people are advancing; workmen want better homes, better clothing, better food, to raise their families in greater comfort, and to give their children better opportunities for education. In addition to these they should have enough to properly provide for their sustenance and comfort in their declining years. In short they want higher wages. Having secured the higher wages, the next thing Labor wants is more leisure for recreation, for the enjoyment of the wealth produced, and for self-development —or shorter hours.

While, at times, we may have our viewpoint twisted by local conditions, or by the means taken to secure the desired result, we must admit that there is a great deal of justice in Labor's demands—as they are in fact only what we are all striving for.

Sooner or later these demands must be met. But how? No one can logically object to workmen receiving higher pay —either in the form of more dollars or lowered cost of living —nor to their working shorter hours, provided society as a whole does not suffer thereby. It must not be forgotten, however, that society is very largely composed of workmen, and that if we simply raise wages and shorten hours without correspondingly increasing production, the result will simply be to diminish the purchasing power of the dollar, as everything will cost more, and society—including the workmen—will be worse off than before.

Higher Wages and Shorter Hours

Where then are the higher wages and shorter hours to come from? An arbitrary shortening of hours without a proportionate increase in production would wipe a great many industries off the map, unless they increased selling prices to offset the higher cost. If this latter expedient is resorted to, the burden falls upon the consumer—who is in the last analysis the workingman—and he profits nothing by his apparent gain. The same is true of an increase of wages without an increase in production. You can't get something for nothing. Even if all of the profits earned by the average company were distributed among the workmen it would not make any very great difference in their pay, especially if the years devoted to the building-up of a business and years of industrial depression are taken into account.

The earning of profits is, under the existing state of affairs, essential to the life of our industrial organization. Where then lies the solution? Perhaps the first and most important thing—although it will probably be the last to be accomplished—is the stabilization of business, the wiping out of constantly recurring periods of *hard times*. This is, however, too big a subject to go into now. A more practical solution—although it will never be an absolute one as long as we have business depressions—lies in the general adoption of scientific management. The development of machinery has

been the means of the great improvement in the condition of society that has taken place during the last century and a half; scientific management, which is the complement of machinery, is the next step, and will make possible the payment of higher wages and shorter hours without decreasing production or increasing cost.

Opposition to Scientific Management

Scientific management has, even as labor-saving machinery or indeed any progressive movement, met with opposition which has not by any means been confined to the workingmen or their champions.

Much of this opposition has been due to misunderstanding or to abuses committed in the name of scientific management. Misunderstanding is gradually being cleared away, but the abuse referred to is harder to cope with. A man whom I greatly admire and respect, who has spent many years in an honest and tireless endeavor to improve the condition of labor, recently wrote me as follows:

I read the debate which occurred relative to the riders attached to the Army Appropriation Bill. I feel certain that had I been in Congress I would have voted in favor of them, not for any opinion that they settled the question or that they decided the merits of any question involved through scientific management, but that it would force a more thorough study of the entire question.

I do not believe that there is sufficient knowledge on the subject and I feel that those who favor or oppose scientific management must discuss their respective attitudes more thoroughly and publicly than they have, before anyone is in a position to speak a final word.

Since leaving you I have seen much which interested, amused and grieved me, and on more than one occasion I said: "If Hathaway could only see this he would have a fit and somebody would be expelled for heresy".

I found many conditions existing in plants which claim to have applied the methods of scientific management which were in direct opposition to the principles laid down by Mr. Taylor and those which you have talked over with me, and one of the most depressing facts which was most evident is that the woods are full of incompetent men and charlatans who,

because the field seems to be a promising one, are out gathering in the shekels from those who have employed them. I feel that these men, who are quite large in numbers, are far more dangerous to scientific management than anything else.

I want to assure you that had you seen some of the second and third rate men whom I have watched making time studies and setting tasks, you would realize the necessity of some such step being taken as much so as if you had witnessed, as I have done, the work of some men professing to be efficiency engineers and received comparatively enormous salaries. These men, are, without doubt, acquiring some information as they blunder along, and it is doubtful who bears the heaviest burden of their experiments, the employers or the workmen. I have seen plenty of instances where one or the other or both were being flim-flammed. As one man standing fairly high among the group of those who advertise their business as efficiency engineers said to me during a conversation—"What in h—l do you think we are. There may be a whole lot of talking about our benefiting the workmen, but the employer is in business for the money and we are in the business for the money. When we feel that we are not in the business for the money that's in it, we will get out". You see it is not only what the words may imply but the spirit which lay back of it and so long as men with such ideals are endeavoring to introduce new systems, so long is it most certain that there will be industrial friction whether the workers are organized or unorganized.

Four Basic Principles of Scientific Management

This sort of thing, of course, is an obstacle in the advancement of scientific management, but as employers and workmen learn more about the subject it will disappear. The essence of scientific management is summed up in four great principles; Mr. Taylor states the four basic principles in his book "The Principles of Scientific Management" in such a concise manner that it is not until he has studied the subject exhaustively and become quite familiar with it through intimate contact that the average person grasps their full meaning and importance. These basic principles are as follows:

1.—The development of a science in place of "rule-of-thumb" knowledge. This means scientific investigation and study; the collection and codification of data and their reduction to laws. In this *time study* plays an obviously important part.

2.—The scientific selection and training of the workman in place of workmen being employed as a result of expediency, necessity, or mistaken personal preference on work for which they may be physically, temperamentally, or mentally unsuited; or, as Mr. Taylor expresses it, "in the past he (the workman) chose his own work, and trained himself as best he could". Improper selection of the workman has resulted in many *square pegs in round holes.*

3.—Hearty co-operation between the management and the men, so as to insure all work being done in accordance with the principles of the science which has been developed.

4.—An almost equal division of the work and responsibility for results between the management and the workmen, the management taking over all of the work for which they are better fitted than the workmen; in the past almost all of the work, and the greater part of the responsibility were thrown upon the men.

Important as these principles may be, it is not enough to simply set them forth. While they may be applied by anyone in any undertaking employing a number of people without any formally laid down system, if they are to be consistently and permanently adhered to a properly devised and installed mechanism becomes a necessity. To the development of such a mechanism Mr. Taylor devoted the greater part of his life.

Time will not permit of any detailed description of the system developed, the form of which varies in different industries. I must take it for granted that you are already familiar with it, and if not, and you wish to become so, I must refer you to Mr. Taylor's book, "Shop Management" and certain articles which you will find reprinted in a book on scientific management published by the Harvard University Press.

In conjunction with reading the books referred to, those who are sufficiently interested would get a still better understanding by visiting one or more of the plants where this system is in operation.

On a Voyage of Discovery

In discussing the application of scientific management to the foundry, I feel something like Columbus must have felt in his endeavors to interest the people of his time in the theory that another continent lay at the opposite side of the globe and

that by sailing due west he would reach it. No one had ever demonstrated that it could be done. That scientific management may be profitably applied to the operation of a foundry is, so far as the writer knows, still to be demonstrated.

In certain quarters this statement may be questioned. I have no doubt that some of you have heard of cases where scientific management has actually been tried, and proved a failure. Others may know of foundries which claim to be successfully operating under scientific management; and I have no doubt that a considerable portion of my readers will admit freely and without wasting time or argument that it may work all right in a machine shop, but that it won't work in their business.

Efforts Have Been Sporadic

From this it must not be presumed that foundrymen have not given much study and effort to the subject of increasing efficiency, or that nothing has been done in the matter of systematizing foundry operation, but that so far such efforts have been sporadic and have not been carried on in a manner which would have, in the eyes of the late Frederick W. Taylor or those who were closely associated with him in the great cause to which he devoted his life, merited the name of scientific management in the same sense as would the accomplishments in other branches of industry.

In dull times, such as prevailed almost generally throughout the foundry industry during the past two years—when most plants ran only three or four days per week with a reduced number of workmen—any proposition to increase production will fall on deaf ears. In such times all that may be accomplished is to reduce the direct labor cost through producing enough more work in a given time. A part of this saving must go to the worker as his just recompense for the part he plays in effecting it, and another part must defray the cost of creating and maintaining those improved conditions in the absence of which the workman could not turn out the increased amount of work. Such saving as may remain under

the circumstances is not sufficient, in view of the increased percentage of fixed charges and other indirect expenses due to decreased business, to justify the expense of developing and installing the requisite system of scientific management. In busy times such as we have known in the past and such as seem now to be before us the problem is how to fill orders.

When the existing plant becomes insufficient to handle the business there are two ways to proceed: The most common and most obvious thing to do would be to make an addition to the plant, but there may be some difficulty in financing such a venture and land may not be available, but assuming that these obstacles do not exist there is still a greater objection than either of them, namely the increase in plant necessary to take care of the business that may be secured in boom times adds just so much more burden to be borne in dull times.

Taylor System Tentatively Applied to a Jobbing Foundry

I shall now very briefly outline a tentative plan for the application of the Taylor system, having in mind a large jobbing foundry.

At this point it might be well to point out that the system or mechanism for the application of the principles of scientific management differs widely in different industries, and even in different plants in the same industry.

The development of a system suitable for each of the different classes of foundries is something that may only be done on the ground under working conditions. Today I doubt, if a company decided to install the Taylor system, that it would be possible to find a man to undertake the work possessing the necessary knowledge of foundry practice and at the same time a sufficiently profound knowledge of scientific management, to say nothing of the experience, ability and temperament upon which its successful installation depends.

It might be done in one of two ways:

a—By an experienced foundryman working in conjunction with an experienced management engineer.

b—By an experienced foundryman—possessing the right qualifications—taking two or three years to train himself; this period to be spent in other industries in which the Taylor system is in operation.

In a foundry we would have, in common with other industries, to establish a planning department, a stores system, a tool room; equipment would have to be put in good condition, standards established, and provision made for maintaining the standards.

The work of the planning department would include, in addition to the ordinary clerical functions, inspection and repair of patterns received, and should have the necessary floor space and equipment for this. Patterns to be used would be brought to the planning department, inspected, and such minor repairs made as might be necessary.

Next the work of molding would be planned and instruction cards written. In this connection the flask to be used would be looked up, cores ordered, and provision made for having on hand all rigging before issuing an order for the actual molding of the job, so that when the time comes everything necessary may be delivered to the molders' floor in good working order.

The planning would include determining whether or not the job should go on a molding machine—if so, which machine—and the fitting up of the pattern for the machine decided upon. The man performing this function would necessarily have to be a thoroughly skilled and practical man.

The need of a tool room has long been recognized in machine shops even where no claim is made to the application of scientific management, but without a properly organized and equipped tool room scientific management would be almost impossible of application.

Tool Room an Important Factor

In a foundry under this system the tool room would be fully as important a factor as in a machine shop. The tool room would have charge of the storage and issue of all flasks, as well as repair and alteration of them. It should be able at

any time to tell just what flasks are in use, what are available, and where located. It should be able to supply all small tools, such as rammers' trowels, shovels, brushes, etc., and should be responsible for the inspection and repair or replacement of those tools which would constitute the molder's regular equipment.

Some effort has been made to work along these lines; that is, to have patterns looked over and fixed up, proper flasks and other equipment supplied in advance of work being given to the molder, even in foundries making no pretense to scientific management, but it is very difficult without organization and system to have it done consistently. Such things, it may be said, should be done by any competent foreman, but when one considers the multiplicity of duties falling upon the foreman of a foundry it is a great compliment to him that he succeeds in keeping the foundry running at all.

What is Expected of the Foreman

I know from experience that in a machine shop it is a physical impossibility for a foreman to do one-half of what is expected of him, and from what I have seen of foundries, the machine shop foreman has an easy job compared to his brother in the foundry.

To illustrate the importance of these points the following instances are cited. In one foundry I saw a flask measuring about 5 x 8 feet and 3 feet deep placed on a jarring machine, filled and rammed up in a remarkably short time, and then left standing on the machine 20 minutes while the molder and his two helpers went in quest of clamps and wedges to secure the bottom board; they would not have taken so long except that the first man whose clamps they stole caught them just as they were putting them on, making it necessary to start the hunt all over again.

It is not infrequent that one sees a pattern sent to the foundry in such a battered condition that it cannot be drawn without so badly damaging the mold as to require more time in patching than the whole operation should take.

The man running a jobbing foundry is naturally reluctant to spend money fixing up someone else's patterns, but it is my firm belief that he would profit by employing a first-class pattern maker to regularly go over and fix up every pattern before it goes to the molder. Such things as this, and going over flasks to make sure that pins and bars are all right, seeing that bottom boards, clamps, gaggers, chaplets, etc., are provided, could probably be done to greater extent than is customary, even without attempting a complete installation of the Taylor methods.

I had not intended to enter into a discussion of the shortcomings of present day foundry management, but cannot refrain from citing a few examples that have come to my attention which serve, I believe, to illustrate the need for something better.

A few years ago C. E. Knoeppel wrote an article appearing in the *Engineering Magazine* describing in a rather humorous way the experience of a molder named "Bill" during his day's work, comparing the time his several jobs took to complete with the time that should have been taken had his work been better planned. Many of you have probably read this article, but if you have not, you ought to do so; you will find it not only amusing, but instructive if read in the proper spirit.

Molding Machine Salesman's Report

The following report from a salesman of a certain molding machine company describing his efforts to help out a customer, is interesting:

Arrived about 2:00 p. m. and went at once to the foundry. Next four days spent in getting acquainted with conditions in works and putting the following improvements under way:

a—New clamping device to hold pattern boards on machine. Saves about six minutes every time a pattern board is changed and prevents danger of injury to patterns.

b—Sprue stick for patterns and a basin on ramming block of machine to cut sprue hole and basin in cope during ramming operation. Saves one-half minute per mold.

c—Sand placed in more convenient location. Saves about one-half minute per mold.

d—Loose floor boards put around machine instead of boards nailed down. Saves at least one hour per week in cleaning out under machine.

e—Benches placed beside machine for tools, parting sand, etc. Save about one minute per mold.

f—Taught *team work* motions to machine operator "Charley", who quit because of size of sand pile being moved to machine.

All of these things could have been done without a man from the outside coming in to do them. It is no reflection on the foreman or superintendent that they were not done. Neither of them could possibly devote enough time to this one problem to work out its solution.

The Shop Under Scientific Management

In a shop under scientific management there would be someone whose sole function is taking care of just such cases.

The following very rough time study was made by the salesman. As a time study it is worthless, but it indicates certain delays which better planning and better service to the workman might have overcome:

FIFTH DAY

Started with "Angelo" and "John", both new to their jobs.

A. M.	A. M.	
7.00	to 7.40	Cutting sand.
7.40	to 7.47	John to toilet.
7.47	to 8.35	16 drags made. About 2 minutes, 43 seconds each.
*8.35	to 8.38	Angelo gets slick from old place in shop.
*8.38	to 8.40	Both men get blacking from benches in foundry.
8.40	to 9.05	Patching and blacking 16 drags.
9.05	to 9.09	One man sets 16 small cores while other man continues to patch and black.
*9.09	to 9.10	One man gets fresh supply, of blacking, while other continues to finish molds.
9.10	to 9.17	Both men nail 15 small cores with 2 nails each.
9.17	to 9.25	Both men set 11 large cores and vent each one at 5 points.
9.25	to 9.32	Changing pattern board.
*9.32	to 9.33	Getting vent wire on account of not understanding that this was not necessary.
9.33	to 9.43	Making first cope. Learning where nails were to be set, etc.
9.43	to 9.50	Adjusting pouring basin on pressure block.
9.50	to 10.20	Making 3 more copes.
*10.20	to 10.23	John gets clay and mixes it in clay wash for nails.
10.23	to 11.08	10 more copes made. 4 minutes, 30 seconds per cope.

A. M. A. M.
11.08 to 11.18 2 more copes made.
11.18 to 11.50 Finishing copes.
11.50 to 11.55 John left for somewhere.
11.55 to 12.00 Finishing copes.
P. M. P. M.
1.00 to 1.55 Finishing and setting five cores in drags.
1.55 to 2.00 Blacking and blowing out molds.
2.00 to 2.07 Tipping up copes and cleaning out basins.
2.07 to 2.21 Closing 16 molds.
*2.21 to 2.26½ Getting facing sand.
2.26½ to 2.28 Changing pattern.
2.28 to 2.31 Getting bull ladle and building fire in it.
2.31 to 3.00 Making 8 drags.
3.00 to 3.03 Changing pattern board.
*3.03 to 3.28 Trouble with pattern. Lost three molds and finally saved one by carefully patching. Allow 6 minutes machine time.
*3.28 to 3.40 Patching eight drag molds.

Molds made 20½. Time on machine, 3 hours, 11 minutes. Average, about 6½ molds per hour.

Sixth Day

"Angelo" and "Luigi", both new to their jobs. On previous day Angelo worked on opposite side of machine.

Started work with 8 drags and 1 cope on the floor.

A. M. A. M.
7.00 to 7.30 Cutting sand. (10 minutes less than on day before).
7.30 to 8.04 Seven copes made.
8.04 to 8.30 Finishing these 7 copes.
8.30 to 8.38 Closing 8 molds.
8.38 to 8.42 Changing pattern.
8.42 to 9.27 Making 15 drags, 3 minutes each.
9.27 to 9.41 Finishing these drags.
9.41 to 9.47 Adjusting block on ramming head.
9.47 to 10.06 Making 3 copes.
10.06 to 10.20 Making 3 more copes.
10.20 to 11.10 Seven copes made.
*11.10 to 11.20 Trouble with flasks not fitting pattern board.
11.20 to 11.29 Two copes made.
11.29 to 12.00 Finishing these copes.
P. M. P. M.
*1.00 to 1.35 Finishing copes. No cores at hand as promised.
1.35 to 1.45 Luigi gets more black sand. Angelo continues to finish molds.
*1.45 to 1.55 Luigi (new man) spoils cope. Angelo patches it.
1.55 to 2.00 Removing basin from pressure block on machine.
2.00 to 2.32 Making 10 drags.
2.32 to 3.00 Closing molds.
3.00 to 3.30 Making 5 copes.
3.30 to 3.40 Closing same.

Twenty-eight molds closed on floor and six extra drags and one extra cope which could not be closed because of flask pins.

Molds made, 26. Time on machine, 4 hours, 13 minutes. Average about 6.2 molds per hour.

SEVENTH DAY

A. M.	A. M.	
7.00 to	7.30	Cutting sand.
*7.30 to	8.15	Cleaning out sand under machine.
8.15 to	10.13	Forty-four drags made.
*10.13 to	10.40	(Allow 3 minutes machine time). Grinding corners off pattern board and adjusting pattern board in place.
10.40 to	12.00	Making 23 copes.
P. M.	P. M.	
1.00 to	1.20	Angelo and Luigi make 2 copes.
1.20 to	3.00	Twenty-six more copes finished. Trouble and delay all through this time because the flasks that were brought to machine did not fit pattern board.

50 open molds on floor.

Molds made, 46½. Time, 5 hours, 21 minutes. Average about 8.7 molds per hour.

Average time for various half molds made. These times can be considerably reduced by practice:

	Time Each	
	Minutes.	Seconds.
Pattern "A" Drags.....	2	43
Pattern "A" Copes.....	4	30
Pattern "B" Drags.....	3	35
Pattern "B" Copes.....	4	54
Pattern "C" Drags.....	2	37
Pattern "C" Copes.....	4	8

I believe these times can be reduced to an average of three minutes per half mold.

The items marked * indicate points at which production was lost through faults over which the workman had no control. A more minute and properly made time study with a sufficient number of observations—such as will be shown later—would have probably indicated numerous small difficulties which if corrected, would result in considerable gain in output.

Planning System

I have not endeavored to describe in detail the planning system which would necessarily have to include some satisfactory means for the laying-out of work for each molder in advance, for the delivery of the patterns, flasks, etc., to him at the right time, for securing reports of each job finished and its inspection, and moving it forward from one operation to the next, as well as making it possible to see just how much work there may be ahead of each class, and a means of knowing just what stage has been reached in the completion of any lot of castings.

As already stated, the details of such a scheme would have to be worked out on the ground, and while a general scheme might be evolved which would serve as a basis for all foundries of a given class, experience teaches us that even in different foundries whose work is in general the same, certain modifications would have to be made.

The working out of such a system is in itself a big undertaking, and likewise is the standardization of conditions and equipment upon which the smooth operation of the system developed will depend.

The several cases of inefficiency cited are not intended to simply show how bad existing foundry management may be, but they serve to illustrate what it is necessary to do in the way of establishing and maintaining better conditions before a system of scientific management may be applied. Strange to say the results achieved under scientific management are dependent upon the establishment and maintenance of better working conditions, and at the same time the establishment and maintenance of better working conditions is dependent upon the system. Under ordinary management it is very difficult to keep things up to the required standard, but under scientific management, where the work is planned to be done in a definite way under certain definite conditions and using certain specified tools and appliances, there is a much greater pressure brought to bear on the management in the matter of maintaining proper conditions.

Time Study and Piece Rates

That phase of the Taylor system which is apt to attract the attention of managers most forcibly is time study and its use in the setting of piece rates, or establishing the time work should take. Many are the crimes committed in the name of *time study,* and little is it understood. Not long ago I heard a lecture describing what purported to be a system of management, and after having set forth in considerable detail the worst kind of a hit-or-miss, man-driving scheme in which the

management made no effort in any way to aid either foreman or workman, and after advocating methods which scientific management would abhor, the lecturer complacently said: "This may sound like the Taylor system, but we have left out all of the undesirable features; we have no shoe-clerks with stop-watches." To anyone familiar with scientific management such statements are so ridiculous as to be laughable, but I regret to say that I do know of cases where young men who have been clerks or just out of college possessing no practical experience have been given stop-watches and sent into shops by managers who, having heard of the results achieved under scientific management, considered time study as the one essential feature, and decided to try it for a few weeks to see if it would accomplish the same results in their plants. Needless to say that in such cases the results are worthless if not disastrous.

The Self-Styled Efficiency Expert

There is also the self-styled efficiency expert who with a stop-watch in each hand and his hands in his pockets attempts to make time studies while trying to appear to the man whose work he is timing to be interested only in a fly crawling along the crane runway.

This is *Not* time study. Such methods are not only an insult to the workmen concerned, but are absolutely of no use.

For a detailed description of the theory of elementary time study I would refer you to an article written some years ago, entitled "Elementary Time Study as a Part of the Taylor System of Scientific Management," which was published in *Industrial Engineering* in 1911, and which has been reprinted in a book, already mentioned, comprising a large number of articles on scientific management by various writers, brought together and edited by C. B. Thompson, and published by the Harvard University Press, Cambridge, Mass.

Time studies should almost never be undertaken except for the purpose of improving methods, and in no case for the purpose of setting tasks until a suitable foundation has been laid. Virtually all of the other features of the system must

be in operation before any attempt is made to make or use time studies. This I cannot too strongly emphasize, and from what I have already said its importance should be obvious.

The Purpose of Time Study

The purposes of time study are as follows:

a—To find the best method both as to quality and time.

b—To locate defects in equipment, or conditions which retard production.

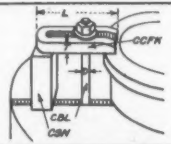
c—To establish standards as to methods, equipment, conditions, and time for doing work.

d—To enable the accurate fixing of time that any job should take without having to make new time studies of every new job, and to use the time thus established in the setting of piece rates that will be right and that will serve as a basis for the increased pay which the workman should receive as proper compensation for his co-operation.

Time study as practiced under the Taylor system does not, except in very highly specialized industries, consist of the study of any given job with reference to the time it should take to do that job alone. This might be the case in a concern manufacturing only one article where the same operators always did the same work. In a foundry, even one manufacturing a standard line of product, the study should be made of each of the small elementary operations entering into the performance of the work. To illustrate this, reference to the instruction cards for making molds on a power squeezer shows that job split up into a great number of minute operations. Many of these operations have to be performed in connection with any job that may be done on this type of molding machine.

They may be briefly classified under the following headings:

Elementary operations concerned with handling machine.
Handling pattern and pattern carrier.
Handling flask.
Shoveling sand.
Handling finished mold.
Setting cores.



MEDIUM SIZE
CCFK

SIZE OF BOLT D	LENGTH OF CLAMP L	THICKNESS OF CLAMP T	WEIGHT OF CLAMP LBS	OZ.
5/8"	10	1 1/4"	3	11
3/4"	11	1 1/2"	6	-
7/8"	12	1 5/8"	7	8
1"	13	1 3/4"	10	8

CCFK

Sizes Given in the Table

Use One **CBL** *and One* **CSN**

TAYLOR ELEMENTARY SYSTEM UNIT TIME

DIAMETER OF BOLT	5/8 AND 3/4				7/8 AND 1					
LENGTH OF BOLT	**6**	**12**	**14**	**18**	**6**	**12**	**18**	**24**	**30**	**36**
TIME FOR CLAMPING *In Minutes*	0.42	0.45	0.45	0.51	0.48	0.53	0.57	0.69	0.78	0.92
Lift Bolt, Clamp and Block to Table, Bolt Remaining in Hand	0.07	0.08	0.08	0.09	0.09	0.10	0.10	0.13	0.14	0.17
Put Bolt in Slot	0.04	0.04	0.04	0.05	0.04	0.04	0.05	0.05	0.06	0.07
Slip Clamp on Bolt and on Work	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.07	0.08
Put Block under Clamp	0.04	0.05	0.05	0.05	0.04	0.05	0.05	0.07	0.08	0.10
Screw Nut Down with Fingers	0.05	0.06	0.06	0.07	0.06	0.07	0.08	0.10	0.11	0.14
Tighten Nut Lightly with Wrench	0.06	0.06	0.06	0.10	0.11	0.12	0.13	0.15	0.17	0.19
Draw Nut Down Tight with Wrench	0.09	0.09	0.09	0.10	0.09	0.10	0.11	0.13	0.15	0.17
TIME FOR REMOVING *In Minutes*	0.16	0.17	0.17	0.18	0.22	0.22	0.24	0.26	0.29	0.33
Loosen Nut with Wrench	0.11	0.12	0.12	0.13	0.17	0.17	0.19	0.20	0.22	0.25
Remove Clamp from Bolt	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.07	0.08
TIME FOR CLAMPING *In Minutes*	0.30	0.33	0.34	0.37	0.35	0.39	0.42	0.51	0.58	0.68
Slip Clamp on Bolt and on Work	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.07	0.08
Put Block under Clamp	0.04	0.05	0.05	0.05	0.04	0.05	0.05	0.07	0.08	0.10
Screw Nut Down with Fingers	0.05	0.06	0.06	0.07	0.06	0.07	0.08	0.10	0.11	0.14
Tighten Nut Lightly with Wrench	0.08	0.08	0.08	0.10	0.11	0.12	0.13	0.15	0.17	0.19
Draw Nut Down Tight with Wrench	0.08	0.09	0.10	0.10	0.09	0.10	0.11	0.13	0.15	0.17
TIME FOR REMOVING *In Minutes*	0.24	0.25	0.25	0.27	0.30	0.30	0.33	0.37	0.41	0.47
Loosen Nut with Wrench	0.11	0.12	0.12	0.13	0.17	0.17	0.19	0.20	0.22	0.25
Remove Clamp from Bolt	0.05	0.05	0.05	0.16	0.05	0.05	0.05	0.05	0.06	0.07
Remove Bolt from Slot	0.03	0.03	0.03	0.04	0.03	0.03	0.04	0.04	0.05	0.05
Put Clamp, Bolt and Block in Tote Box on Floor	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.08	0.08	0.10

CLAMPING
BOLT TO BE PUT IN SLOT
The Time Given in this Section to Be Used ONLY FOR FIRST PIECE *in Lot or on other Pieces* WHEN BOLT HAS TO BE PUT INTO SLOT.

REMOVING
BOLT NOT TO BE TAKEN FROM SLOT
The Time Given in this Section to Be Used for All Pieces in Lot EXCEPTING THE LAST PIECE.

CLAMPING
BOLT ALREADY IN SLOT
The Time Given in this Section to Be Used for All Pieces in the Lot AFTER *the* FIRST PIECE *When Bolt has Not Been Removed.*

REMOVING
BOLT TO BE TAKEN FROM SLOT
The Time Given in this Section to Be Used ONLY FOR LAST PIECE *in Lot or on other Pieces* WHEN BOLT HAS TO BE TAKEN FROM SLOT.

FIG. 1—DATA SHEET OF MACHINE SHOP TIME STUDY COVERING THE PUTTING ON AND TIGHTENING A BOLT AND CLAMP OF A GIVEN SIZE

The illustrations given show time studies made in two different foundries on different jobs, and it is interesting to note that the same elements performed by different men at different times correspond very closely in the matter of time taken for their performance, and that if we eliminate those elements appearing in the job requiring the longer time we have practically the same time as is indicated for the job requiring the shorter time.

It will be apparent that any two jobs of the same general character will include a large number of the same elements, some being included in one job that do not appear in the other, and the sequence in which the elements occur may be different in each.

Consequently, what should be done is to make complete time studies of all of the different elements entering into the art of molding, properly tabulate and classify these data, and by putting the elements entering into any given job together in their proper order with the time for each, the time that the particular job in question should take may be arrived at. The fact must again be emphasized, however, that the time set based upon elementary time studies of this sort which were taken under proper working conditions with flasks, patterns, etc., in first class working conditions, would be absolutely useless and improper if standard conditions were not first established and maintained; therefore, it is absolutely necessary to establish such a system as has been briefly outlined for planning the work, providing all necessary equipment and materials, so that they will be on hand when wanted, before any attempt is made in the matter of time study, or the setting of tasks, or piece rates on a basis of elementary time study.

Time Studies in Machine Shop Work

The following illustrations of time studies applying to machine shop work may help to make this point clearer. Referring to the data sheet, Fig. 1, it will be noted that the workman is allowed a certain time for putting on and tighten-

PR

The Time Given on this Sheet is for all Tools in this Class When Used in Tool Posts as Shown in Sketches.

$\frac{1}{2} \times \frac{3}{4}$ TO $1 \times 1\frac{1}{2}$

TAYLOR ELEMENTARY SYSTEM UNIT TIME

SIZE OF TOOL	WIDTH	1/2	5/8	3/4	7/8	1
	DEPTH	3/4	1	1 1/8	1 3/8	1 1/2
TIME FOR PUTTING IN *In Minutes*		0.40	0.44	0.58		
Select Tool From Tray		0.03	0.03	0.04		
Measure Height of Cutting Edge		0.07	0.07	0.07		
Select Packing to Bring Cutting Edge to Height of Center		0.08	0.09	0.09		
Put Tool and Packing in Tool Post		0.03	0.04	0.04		
Tighten Screw Down Lightly on Tool with Wrench		0.03	0.04	0.04		
Knock Tool Around in Position		0.06	0.07	0.13		
Tighten Screw Down Hard with Wrench		0.06	0.06	0.12		
Remove Wrench and Place on Tray		0.03	0.04	0.05		
TIME FOR REMOVING *In Minutes*		0.17	0.18	0.18		
Pick Up Wrench		0.03	0.03	0.03		
Put Wrench on Set Screw		0.02	0.02	0.02		
Loosen Set Screw		0.08	0.08	0.08		
Remove Tool and Packing		0.02	0.03	0.03		
Replace Tool and Packing on Tray		0.02	0.02	0.02		
Leave Wrench on Tool Post						
TIME FOR PUTTING IN *In Minutes*				0.76		0.78
Select Tool from Tray				0.04		0.04
Measure Height of Cutting Edge				0.07		0.07
Select Packing to Bring Cutting Edge to Height of Center				0.09		0.09
Put Tool and Packing in Tool Post				0.11		0.13
Tighten Two Set Screws Down Lightly on Tool with Wrench				0.17		0.17
Knock Tool Around in Position				0.12		0.12
Tighten Two Set Screws Down Hard with Wrench				0.13		0.13
Remove Wrench and Place on Tray				0.03		0.03
TIME FOR REMOVING *In Minutes*				0.39		0.39
Pick Up Wrench				0.05		0.05
Put Wrench on Set Screw				0.02		0.02
Loosen First Set Screw				0.05		0.05
Move Wrench to Second Set Screw				0.02		0.02
Loosen Second Set Screw				0.08		0.08
Remove Tool and Packing				0.06		0.06
Replace Tool and Packing on Tray				0.09		0.09

PUT TOOL IN TOOL POST HAVING ONE SET SCREW

See Sketch No.1 at Top of Sheet.

REMOVE TOOL FROM TOOL POST HAVING ONE SET SCREW

See Sketch No.1 at Top of Sheet.

PUT TOOL IN TOOL POST HAVING TWO SET SCREWS

See Sketch No.2 at Top of Sheet.

REMOVE TOOL FROM TOOL POST HAVING TWO SET SCREWS

See Sketch No. 2 at Top of Sheet.

FIG. 2—ANOTHER DATA SHEET OF A MACHINE SHOP TIME STUDY

ing a bolt and clamp of a given size. If as is the case in many shops, the workman is first required to find the bolt required and then, if the bolt is too long he has to hunt up washers to fill in the excess length between the nut and the clamp; or if he finds that the thread has been damaged, which requires him to screw the nut down with a wrench instead of spinning it on with his fingers and using a wrench only to pull it up tight, it will be utterly impossible for him to perform this elementary operation in the time given; and this in turn will result in his failure to accomplish the entire job in the time set.

Under the old system the management felt little if any responsibility for such small matters as this, but under scientific management, instead of it being nobody's duty or anybody's duty to look after such matters it becomes the duty of certain specific people, and any failure on their part to properly perform their duties immediately becomes apparent. Under the old scheme, both in day work and piece work shops, the workman suffers constant injustice, being held responsible for producing a large day's output but receiving little help and co-operation from the management. Under scientific management the management must assume its proper share of the responsibility, and must by co-operating with the workman deserve the co-operation it expects of him.

How Time Studies Are Made

Fig. 3 shows how time studies are made. First the operation is separated into its elements, which are listed under the heading, "Detail Operations". In doing this the time study man must have in mind so dividing the work up as to have the individual time for as many elements as possible, which may be useful on other work.

The time is taken with a running watch, and by subtraction, the time for each element is reached and entered under the headings "Individual Time". The sheet shown provides for ten observations of each element, but it is customary to make a larger number.

In selecting from the observations the standard or flat time for each element it is customary to select that which occurs

OBSERVATION SHEET

OBSERVER'S NAME **MACHINE No.** **DATE** 19

WORKMAN'S NAME AND QUALIFICATIONS

PIECE M 10 32 4 J. R. Flask 10 x 16 Cope 4" Drag 3"

DETAIL OPERATIONS	Continuous Time	Individual Time	Continuous Time	Individual Time	Continuous Time	Individual Time	Continuous Time	Individual Time	Continuous Time	Individual Time	Continuous Time	Individual Time	Continuous Time	Individual Time	Continuous Time	Individual Time	Continuous Time	Individual Time	Continuous Time	Individual Time	Continuous Time	Individual Time	Minimum Time
Clean platen & put match & frame in place Clean frame..	4	04	4	04	3	03	3	03	3	03	3	03	3	03	3	03	4	04	3	03	.03
1 Separate cope & drag	7	03	6	02	5	02	5	02	6	03	5	02	5	02	5	02	7	03	5	02	.02
2 Clamp drag (1 cl'mp)	10	03	9	03	8	03	9	04	9	03	10	05	8	03	8	03	10	03	9	04	.03
Put drag in place on hard sand match ..	13	03	13	04	11	03	12	03	14	05	15	05	11	03	14	06	13	03	13	04	.04
Sprinkle with parting	18	05	18	05	17	06	20	08	20	06	23	08	17	06	21	07	19	06	20	07	.06
3 Put riddle on drag..	21	03	21	03	20	03	23	03	22	02	26	03	20	03	24	03	22	03	23	03	.03
4 Put sd. in R (1 shv.)	26	05	25	04	25	05	28	05	27	05	31	05	28	08	29	05	27	05	28	05	.05
5 Riddle.....	31	05	31	06	28	03	33	05	33	06	38	07	34	06	36	07	33	06	35	07	.06
6 Hang R on nail.....	33	02	33	02	30	02	35	02	35	02	40	02	36	02	38	02	35	02	37	02	.02
Fill drag with sand.	40	07	40	07	36	06	40	05	40	05	47	07	41	05	43	05	41	06	42	05	.06
Jar (10 jolts).....	46	06	46	06	41	05	46	06	49	09	52	05	47	06	49	06	48	07	49	07	.06
Strike off & put bottom bd. in place...	56	10	52	06	49	08	52	06	54	05	59	07	54	07	57	08	55	07	57	08	.07
7 Swing yoke forward.	59	03	54	02	51	02	54	02	56	02	62	03	57	03	59	02	57	02	60	03	.02
8 Squeeze drag.....	63	04	58	04	55	04	59	05	60	04	66	04	61	04	64	05	62	05	65	05	.04
9 Swing yoke back....	65	02	60	02	57	02	61	02	62	02	68	02	63	02	66	02	64	02	67	02	.02
Roll over.....	70	05	65	05	62	05	66	05	66	04	73	05	68	05	71	05	69	05	72	05	.05
Put hard sand match on table.....	73	03	68	03	65	03	69	03	69	03	76	03	71	03	74	03	72	03	75	03	.03
2 Clamp cope half of flask (1 clamp)....	76	03	72	04	70	05	73	04	73	04	80	04	74	03	78	04	77	05	78	03	.03
Put cope in place...	80	04	75	03	74	04	77	04	77	04	89	09	77	03	83	05	81	04	82	04	.04
Sprinkle with parting	88	08	81	06	81	07	83	06	82	05	91	02	83	06	90	07	87	06	89	07	.06
3 Put riddle on cope..	91	03	84	03	84	03	86	03	85	03	94	03	86	03	93	03	90	03	92	03	.03
4 Put sd. in R (1 sh'vl)'	95	04	90	06	89	05	91	05	90	05	98	04	90	04	98	05	95	05	96	04	.05
5 Riddle.....	99	04	94	04	94	05	96	05	95	05	3	05	95	05	2	04	0	05	1	05	.05
6 Hang R on hook....	1	02	96	02	96	02	98	02	97	02	5	02	97	02	4	02	2	02	3	02	.02
Fill cope with sand..	9	08	1	05	2	06	5	07	7	10	11	06	4	07	10	06	8	06	9	06	.07
Tuck with hands....	16	07	9	08	8	06	11	06	15	08	19	08	10	06	17	07	15	07	15	06	.07

XUM

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OBSERVATION SHEET

OBSERVER'S NAME **MACHINE No.** **DATE** . 19

WORKMAN'S NAME AND QUALIFICATIONS

PIECE M 10 32 R. Flask 12 x 12. Cope 5″ Drag 4″.

DETAIL OPERATIONS	Con-tin-uous Time	Indi-vid-ual Time	Con-tin-uous Time	Indi-vid-ual Time	Con-tin-uous Time	Indi-vid-ual Time	Con-tin-uous Time	Indi-vid-ual Time	Con-tin-uous Time	Indi-vid-ual Time	Con-tin-uous Time	Indi-vid-ual Time	Con-tin-uous Time	Indi-vid-ual Time	Con-tin-uous Time	Indi-vid-ual Time	Con-tin-uous Time	Indi-vid-ual Time	Con-tin-uous Time	Indi-vid-ual Time	Mini-mum Time
1 Separate C. & D.	1	01	1	01	1	01	1	01	1	01	1	01	1	01	2	02	1	01	2	02	.01
2 Clamp C. (1 clamp)	3	02	3	02	3	02	5	04	3	02	4	03	3	02	4	02	4	03	5	03	.03
Clean platen & put cope in place	7	04	6	03	8	05	8	03	6	03	8	04	8	05	9	05	7	03	8	03	.03
Put m'tch pl. in pl'ce	11	04	10	04	12	04	12	04	9	03	12	04	11	03	12	03	10	03	11	03	.03
Clean plate with bl. valve					15	03														per pc.	.03
Clamp drag (2 cl'ps)	15	04	13	03	20	05	19	07	13	04	15	03	15	04	17	05	14	04	15	04	.04
Put drag in place	20	05	20	07	25	05	23	04	18	05	21	06	20	05	22	05	20	06	20	05	.05
Sprinkle part'g on D	24	04	26	06	30	05	27	04	22	04	25	04	25	05	26	04	24	04	24	04	.04
3 Put riddle on drag	27	03	28	02	33	03	30	03	24	02	27	02	27	02	28	02	27	03	27	03	.02
4 Put 1 shov. sd. on R.	33	06	33	05	38	05	36	06	29	05	32	05	32	05	32	04	31	04	32	05	.05
5 Riddle sd. in D. *	40	07	42	09	45	07	40	04	37	08	37	05	39	07	41	09	40	09	41	09	.07
6 Hang R. on hook	42	02	44	02	47	02	42	02	39	02	39	02	41	02	43	02	42	02	43	02	.02
Fill drag with sand †	50	08	52	08	57	10	49	07	47	08	47	08	47	06	52	09	50	08	51	08	.08
Tuck with shovel	59	09	61	09	65	08	58	09	55	08	55	08	56	09	60	08	59	09	60	09	.09
Strike off & put bottom bd. in place. **	67	08	70	09	76	11	67	09	63	08	63	08	65	09	70	10	68	09	68	08	.09
Roll over	72	05	75	05	81	05	72	05	68	05	70	07	70	05	75	05	73	05	73	05	.05
Sprinkle part'g on pl.	77	05	80	05	86	05	78	06	75	07	76	06	75	05	79	04	77	04	78	05	.04
3 Put riddle on cope	79	02	83	03	88	02	80	02	77	02	78	02	77	02	81	02	79	02	80	02	.02
4 Put 1 shov. sd. in R.	84	05	88	05	94	06	85	05	82	05	84	06	82	05	86	05	84	05	85	05	.05
5 Riddle sand n cope†	90	06	94	06	0	06	91	06	88	06	90	06	88	06	93	07	91	07	92	07	.06
Hang riddle on hook	92	02	96	02	2	02	93	02	90	02	92	02	90	02	95	02	93	02	94	02	.02
Fill cope with sand..†	97	05	0	04	7	05	99	06	95	05	97	05	95	05	0	05	98	05	98	04	.05
Tuck with hands	03	06	6	06	13	06	5	06	2	07	3	06	1	06	6	06	4	06	5	07	.06
11 Strike off & put cope bd. in place. ††	12	09	14	08	21	08	13	08	10	08	12	09	8	07	14	08	11	07	12	07	.07
7 Swing yoke forward	15	03	17	03	24	03	16	03	12	02	14	02	11	03	16	02	13	02	14	02	.02
8 Squeeze	19	04	21	04	28	04	21	05	16	04	19	05	15	04	20	04	17	04	18	04	.04
9 Swing yoke back	21	02	23	02	30	02	23	02	18	02	21	02	17	02	22	02	19	02	20	02	.02
Put cope bd. on table	23	02	26	03	32	02	25	02	21	03	23	02	20	03	24	02	21	02	21	01	.02
10 Cut sprue	27	04	30	04	37	05	30	05	26	05	28	05	24	04	29	05	26	05	28	07	.05

12	Blow off excess sand	35	08	37	07	45	08	36	06	33	07	34	06	30	06	35	06	33	07	32	04	.06
	D aw cope	37	02	40	03	48	03	39	03	37	04	38	04	33	03	38	03	38	05	37	05	.04
	Lay cope on bench	41	04	45	05	52	04	43	04	41	04	43	05	38	05	42	04	42	04	41	04	.04
	Draw plate	50	09	57	12	63	11	52	09	49	08	51	08	49	11	50	08	52	10	49	08	.08
	Lay plate on yoke	53	03	60	03	66	03	55	03	52	03	54	03	52	03	53	03	53	01	52	03	.03
	Pick up cope bring to flask—blow out spr.	59	06	66	06	71	05	61	06	57	05	59	05	57	05	59	06	59	06	57	05	.05
	Close mold	63	04	70	04	76	05	65	04	62	05	63	04	63	06	64	05	64	05	63	06	.05
	Open flask	68	05	75	05	81	05	70	05	66	04	69	05	67	04	69	05	69	05	68	05	.05
	Set flask on floor	71	03	78	03	84	03	73	03	69	03	73	04	70	03	72	03	73	04	71	03	.03
	Round off edges of mold	74	03	81	03	88	04	78	05	73	04	76	03	74	04	75	03	76	03	75	04	.04
	Carry away (15 ft.)	82	08	91	10	97	09	86	08	81	08	84	08	82	09	84	09	84	08	84	09	.08
	Return	89	07	97	06	3	06	93	07	87	06	90	06	87	05	90	06	90	06	90	06	.06
																						1.85

* Clean plate..... 1.25
† Drag patt. deeper & requires more sand than cope.
‡‡ Bottom' board is picked up from floor
†† Cope bd is picked from table.

M 10 32 R Alum match plate. Conditions right.

FIG. 4—ANOTHER SERIES OF OBSERVATIONS MADE ON A DIFFERENT JOB, WITH A DIFFERENT MACHINE AND A DIFFERENT OPERATOR

fers only by one hundredth of a minute, which might be error in reading the watch.

Fig. 5 is an illustration of a time study taken not only with another operator but in another shop, the work being done on the same type of machine as that of Fig. 3, but slightly smaller.

Referring back to the question of fatigue and allowance for other exigencies, it is customary to make continuous observations for one or more days' runs, and by analyzing and charting the results the proper allowance to be added is reached for each class of work. This will be found to vary according to whether the work is simple or complicated, the number of times a cycle of elementary operations is to be repeated, and the extent to which different muscles are used, the weights handled, etc.

Two instruction cards, Figs. 6 and 7, are shown on which an allowance of 20 per cent is added to the

OBSERVATION SHEET

OBSERVER'S NAME **MACHINE No.** **DATE** 19

WORKMAN'S NAME AND QUALIFICATIONS

PIECE M 8 30 R. Flask 19½ x 10½ Cope 3½" Drag 3"

DETAIL OPERATIONS	Continuous Time	Individual Time	Continuous Time	Individual Time	Continuous Time	Individual Time	Continuous Time	Individual Time	Continuous Time	Individual Time	Continuous Time	Individual Time	Continuous Time	Individual Time	Continuous Time	Individual Time	Continuous Time	Individual Time	Continuous Time	Individual Time	Minimum Time
Separate c & d	1	01	1	01	1	01	1	01	1	01	1	01	1	01							.01
Clamp d (1 clamp)	6	05	4	03	4	03	4	03	4	03	6	05	4	03							.03
Put d on platen	10	04	7	03	7	03	7	03	6	02	12	06	7	03							.03
Put plate on drag	13	03	10	03	12	05	10	03	9	03	16	04	11	04							.03
Sprinkle plate with parting	18	05	17	07	17	05	15	05	16	07	23	07	16	05							.05
Put R. on plate	20	02	19	02	19	02	17	02	18	02	25	02	18	03							.02
Put handful core sd. in R	24	04	23	04	23	04	20	03	22	04	29	04	21	03							.04
Riddle	26	02	27	04	27	04	24	04	25	03	33	04	25	04							.04
Put shovel sd. in R	32	06	32	05	33	06	31	07	30	05	37	04	30	05							.05
R	38	06	43	11	40	07	39	08	37	07	43	06	36	06							.07
Hang R. on hook (on wall over yoke)	39	01	44	01	41	01	40	01	38	01	44	01	37	01							.01
Tuck with hands	47	08	52	08	49	08	47	07	47	09	53	09	45	08							.08
Strike off	67	20	71	19	70	21	63	16	60	13	64	11	61	16	Must very	be clean	done ly.				.01
Blow off & clean pl'te thoroughly	84	17	86	15	88	18	76	13	77	17	95	31	76	15							.15
Put false pl'te in pl'ce	91	07	94	08	96	08	83	07	83	06	1.03	08	6	06							.07
Clamp C. (1 clamp)	97	06			0	04	88	05	89	06	7	04	11	05	Includes moving						.05
Put C. on D	5	07	0	06	5	05	92	04	94	05	11	04	17	06	to be nch.						.05
Roll over (Empty fla. except for cheek)	8	03	5	05	9	04	0	08	99	05	15	04	21	04							.04
Sprinkle with parting	12	04	9	04	13	04	4	04	4	05	19	04	25	04							.04
Put R. on flask	14	02	11	02	15	02	6	02	6	02	21	02	27	02							.02
							15	09	16	10											
Put 1 shovel sd. in R.	20	06	18	07	24	09	20	05	21	05	26	05	33	06							.05
R	26	06	23	05	30	06	27	07	26	05	30	04	38	05							.05
Hang R. on hook	27	01	24	01	31	01	28	01	27	01	31	01	39	01							.01
Tuck with hands	35	08	28	04	37	06	35	07	34	07	38	07	45	06							.06

Fill D. with sd. (1 shovel	43	08	36	08	42	05	42	07	41	07	44	06	51	06	....	....	....	....	....	....	.07
Pein with peiner	55	12	54	18	59	17	59	17	57	16	62	18	68	17	....	....	....	....	....	....	.07
Strike off & put b. bd. in place	69	14	66	12	73	14	70	11	72	15	79	17	82	14	Includes picking up B. from pile 5 feet away.						.16
Rap bd. in place with peiner	72	03	72	06	78	05	77	07	76	04	84	05	88	06	....	....	....	....	....	....	.14
Roll over	83	11	85	13	86	08	89	12	84	08	91	07	96	08	....	....	....	....	....	....	.06
Sprinkle	88	05	90	05	91	05	92	03	88	04	97	06	2	06	....	....	....	....	....	....	.08
Put R. on C	90	02	92	02	93	02	95	03	90	02	99	02	4	02	....	....	....	....	....	....	.05
Put 1 shov. sd. in R.	5	05	5	05	5	05	7	07	5	05	6	6	6	06	5	05	6	06	5	05	.02
Riddle	10	05	10	05	9	04	11	04	9	04	10	04	11	05	9	04	12	06	9	04	.05
Hang R. on hook	12	02	11	01	10	01	12	01	10	01	11	01	12	01	10	01	13	01	10	01	.05
Tuck with hands	20	08	19	08	19	09	21	09	18	08	19	08	21	09	19	09	22	08	15	05	.01
Fill with sd. (1 shov.)	29	09	28	09	26	07	30	09	25	07	26	07	27	06	26	07	31	09	21	06	.08
Pein with peiner	47	18	46	18	42	16	45	15	42	17	42	16	42	15	43	17	50	19	37	16	.07
Strike off—put C. bd. in place (carried on bench)	58	11	58	12	55	13	56	11	51	09	52	10	52	10	54	11	61	11	8	08	.16
Swing yoke forward	60	02	60	02	2	02	58	02	53	02	54	02	54	02	56	02	63	02	10	02	.11
Push flask back	62	02	62	02	4	02	66	08	55	02	58	04	57	03	58	02	65	02	13	03	.02
Squeeze	67	05	67	05	9	05	....	....	61	06	63	05	62	05	64	06	70	05	18	05	.05
Swing yoke back	69	02	69	02	10	01	67	01	62	01	64	01	63	01	65	01	71	01	19	01	.02
Remove C. bd	73	04	73	04	14	04	70	03	66	04	69	05	69	06	69	04	76	05	23	04	.01
Cut sprue (cutter on yoke)	78	05	78	05	19	05	76	06	70	04	75	06	73	04	75	06	82	06	28	05	.04
Blow off	85	07	86	08	26	07	88	12	78	08	84	09	80	07	85	10	90	08	38	10	.05
									26	....											.08
Rap	93	08	95	09	33	07	90	02	33	07	92	08	86	06	93	08	94	04	44	06	.06
Draw C	2	09	5	10	42	09	3	13	42	09	2	10	95	09	4	11	6	12	54	10	.10
Put C. on bench	5	03	8	03	46	04	7	04	46	04	5	03	0	05	8	04	9	03	58	04	.04
Blow off plate	9	04	13	05	54	08	12	05	54	08	9	04	5	05	15	07	13	04	64	06	.04
Draw false plate—put on fl	13	04	17	04	59	05	15	03	59	05	13	03	11	06	19	04	17	04	68	04	.05
Sprinkle cheek with graphite	23	10	30	13	1.25	....	26	11	70	11	23	10	29	18	30	11	29	12	79	11	.04
Blow off	29	06	35	05	32	07	35	09	75	05	28	05	34	05	38	08	34	05	85	06	.11
Bring D. to C	33	04	38	03	37	05	39	04	80	05	33	05	39	05	42	04	38	04	90	05	.09
Close	43	10	45	07	44	07	48	09	90	10	44	11	45	06	52	10	46	08	1	11	.04
Put C. bd. in place	47	04	50	05	49	05	51	03	95	05	48	04	49	04	58	06	49	03	5	04	.08
Roll over	58	11	57	07	56	07	58	07	1	06	55	07	56	07	65	07	56	07	13	08	.04
Draw drag	63	05	63	06	60	04	63	05	6	05	60	05	60	04	71	06	60	04	17	04	.07
Put on bench	67	04	66	03	64	04	67	04	10	04	64	04	64	04	74	03	64	04	21	04	.04
Draw plate	74	07	74	08	70	06	73	06	17	07	70	06	74	10	84	10	72	08	26	05	.04
Put plate on yoke	76	02	77	03	72	02	75	02	19	02	72	02	76	02	86	02	75	03	28	02	.06
Repair mold (pc)	....	....	....	....	....	....	....	....	....	....	....	....	85	09	1.09	.23	....	....	....	....	.02
Bring D. to C	80	04	80	03	78	06	91	04	26	07	78	06	0	15	13	04	80	05	32	04	.02
																					.04

(Continued on Page 112)

(*Continued from Page 111*)

Close mold	3	03	26	...	3	03	3	03	3	03	3	03	3	03	3	03	3	03	3	03	3	03	2	02	.03
Roll over	10	07	29	03	10	07	8	05	9	06	9	06	11	08	8	05	9	07	.07
Remove C. bd.—put on bench	13	03	39	03	13	03	11	03	12	03	12	03	13	02	11	03	13	03	.03
Unclamp flask	16	03	42	03	16	02	14	03	14	02	14	02	15	02	13	02	15	02	.02
Remove flask—put on bench	29	13	46	04	21	05	20	05	19	05	22	06	19	05	21	06	22	09	21	06	.06
Slick up mold	42	13	59	13	35	14	29	09	27	06	32	10	28	09	33	12	32	10	34	13	.12
Carry out	47	05	66	07	40	05	38	09	34	07	39	07	34	06	40	07	39	07	39	05	.07
Put on floor	50	03	68	02	42	02	41	03	38	04	42	03	37	03	43	03	42	03	42	03	.03
Return	54	04	73	05	47	05	46	05	43	05	47	05	42	05	48	05	47	05	46	04	.05
Clean up and mach.	time	per mold	...	...	...	...	...	...	Time per mold	...	...	...	...	...	...	...	...	...	...	...	.02
Clean plate, 20 molds	50	...	...	...	...	...	...	...	Time per mold	...	...	...	...	...	...	...	...	...	...	...	.02
Clean pins 20 molds	10	...	20	...	...	...	...	...	Time per mold	...	...	...	...	...	...	...	...	...	...	...	.01
										20%	on handling time										4.03 .81
																					4.84

Time for 75 molds 6 hrs., 3 min.
Time taken 75 molds 6 hrs., ½ min.

FIG. 5—RECORD OF TIME STUDY TAKEN WITH ANOTHER OPERATOR IN ANOTHER SHOP, WORK BEING DONE ON SAME TYPE, BUT SMALLER MACHINE THAN SHOWN IN FIG. 3.

flat time; on large, difficult jobs where only one or two are made it would probably be more, as on repetition work after the first few molds a man goes through the cycle of elementary operations more or less automatically; while on a complicated job which may be done only once there is a certain pause between each element, or in other words, time to think must be allowed.

Rest periods are very important on repetition work, and it may be demonstrated that a larger day's output will be produced if the operator rests absolutely for a certain number of minutes at regular intervals than if he tries to keep going steadily all day. If proper rest periods are taken, not only will a larger output result, but the worker will not be unduly fatigued at the end of the day. The right time for the rest periods as well as the intervals between them must be determined by experiment for each class of work.

I do not mention this matter of guarding against fatigue solely from sentimental or humanitarian motives, but because it is just as necessary, if not more so, to conserve the well-being of the man who runs the machine as it is to keep up to the standard the implements and conditions upon which his production depends. The pugilist may box 40 rounds of three minutes each with the customary rest between each round, making two hours of actual activity, and come out in fairly good condition; but probably no man living could keep on boxing two hours straight away.

Confidence Between Time Study Man and Workman

There must exist a feeling of perfect confidence between the time study man and the man doing the work. As a matter of fact it is a team proposition, and the workman must, if he is to perform his part in an intelligent manner, understand the whole proposition. Everything must be open and above board. I do not approve at all of making time studies in secret, nor behind closed doors. They should be made out in the shop under working conditions.

This can only give you a general idea of time study and the part it plays in scientific management, but I hope it will make clear the fact that it is not a thing to be taken up without a full understanding of what it involves.

It would seem that there is no more fertile field nor any industry requiring scientific management more than the foundry. Great progress has been made in the metallurgical branch of foundry practice, but much of its benefit is lost due to the lack of a proper system and organization in the foundry for putting into practice the results of the metallurgist's work.

I have in mind a foundry which made several classes of work calling for totally different mixtures, a part of its work being machinery castings which were to be soft, and another part being castings which were to be hard, and in spite of the maintenance of a metallurgical laboratory, there were all too frequent instances of the castings which should have been hard being soft and those which should have been soft being hard.

INSTRUCTION CARD FOR OPERATION. Pattern "10X"

SHEETS, SHEET No.		Drawing No.	Machine No. M 8 30 R	ORDER No.
MATERIAL	CLASS No.	Pieces in Lot	Time for Lot	BONUS

DESCRIPTION OF OPERATION.—Molder closes molds. Carries out molds. Albany sand used. Sand pile located on right of machine. Table for holding flask and cope board to left. Riddle hung on hook within convenient reach on the right. Sprue carried on Ramming Block.

1	Patt. Plate laid on Yoke while closing and carrying out molds		
2			
3	Number of patterns per flask=4		
4	Wooden snap flask. 12 x 12 — 4 — 5		
5	Cu. in. capacity 1296		
6	Weight of mold, 47 lbs		
7	Weight rolled over by Molder, 72 lbs		
8	Weight carried out by Molder, 51 lbs		
9	Weight of flask only, 26 lbs		
10	Weight of patt. plate and vibrator, 13 lbs		
11			
12			
13	(NO PREPARATION TIME ALLOWED)		
14			
15	Separate cope and drag halves of flask	.01	
16	Clamp cope half of flask (1 clamp)	.03	
17	Clean platen and put cope in place (bottom up)	.03	
18	Put match plate in place on cope	.03	
19	Blow off pattern plate every 10 molds (per pc.)	.03	
20	Clamp drag half of flask (2 clamps)	.04	
21	Put drag in place on pattern plate	.05	
22	Sprinkle pattern plate with parting	.04	
23	Put riddle on drag	.02	
24	Put 1 shovel of sand in riddle	.05	
25	Riddle sand onto pattern plate	.07	
26	Hang riddle on hook	.02	
27	Fill drag with sand (2 shovels of sand)	.08	
28	Tuck with shovel handle	.09	
29	Strike off and put bottom board in place	.09	
30	Roll over	.05	
31	Repeat items 22 to 24 inclusive	.11	
32	Riddle sand onto pattern plate	.06	
33	Hang riddle on hook	.02	
34	Fill cope with sand (1 shovel of sand)	.05	
35	Tuck with hands	.06	
36	Strike off and put cope board in place	.07	
37	Swing yoke forward	.02	
38	Squeeze mold 65 lbs. per sq. in	.04	
39	Swing yoke back	.02	
40	Put cope board on table (start cutting sprue before		
41	cope board is actually on table)	.02	
42	Cut sprue	.05	
43	Blow off excess sand	.06	
44	Draw cope	.04	
45	Lay cope on table	.04	
46	Draw pattern plate	.08	
47	Lay plate on yoke	.03	
48	Pick up cope—blow out sprue—bring to drag	.05	
49	Close mold	.05	
50	Open flask (unclamp three clamps)	.05	
51	Set flask on table—cope half up	.03	
52	Round off edges of mold	.04	
53	Carry mold out and set on floor (15 feet)	.08	
54	Return to machine	.06	
		1.86	
	30 per cent on handling time	.56	
		2.42	

Time for lot = (No. of molds x 2.42)
Time for 50 molds=121.00 or 20 tenths

WHEN WORK CANNOT BE DONE AS ORDERED GANG BOSS MUST MUST AT ONCE REPORT TO MAN WHO SIGNED THIS CARD

Mon. Day Year

Signed F. R. W.

Checked

FIG. 6—INSTRUCTION CARD FOR OPERATION

As far as could be determined this resulted from insufficient control or the lack of adequate system and supervision in the charging of the cupolas, the pouring, and in segregating the different grades of scrap.

Analysis Thrown Into Every Charge

Another case which came to my attention was that of a concern which had been having trouble with its castings and employed a metallurgist to work out an analysis and formula to serve as a guide for the foundrymen in melting, but still its castings continued to be hard or defective. The manager of the concern sent for the foundryman and questioned him as to whether or not he was making proper use of the information supplied by the metallurgist, and received the following reply: "Mr. Jones, I can't understand why that iron doesn't come right because I have put a piece of paper containing the analysis into the cupola with every charge."

In the matter of molding and pattern fitting there are a great many questions which should be worked out on a scientific basis such as the question of venting, questions concerning the kinds of sand, etc., which different individuals are trying to work out in their own way, frequently arriving at widely varying conclusions, and the same problems being worked out over and over again with considerable waste of energy. This brings me up to my chief object in writing this paper, which is to advocate to this society a plan.

Recommendations

There is a most unfortunate lack of definite objects and definite action to obtain those objects evident in nearly all technical societies today. Progress in the art with which the various societies are concerned is dependent upon individuals working out a solution of problems encountered, many of which affect not only the individual concerned, but all others engaged in the same industry. It is left to chance, to the disposition of the individual, to bring the results of his work before the society. In some cases he does so, but in many

INSTRUCTION CARD FOR OPERATION Pattern 10 "X"

SHEETS, SHEET No.		Drawing No.	Machine No. M 8 30 R	ORDER No.	
MATERIAL	CLASS No.	Pieces in Lot	Time for Lot	BONUS	

DESCRIPTION OF OPERATION—OPERATIONS PERFORMED BY MOLDER
Supplies sand. Cuts over sand. Sets cores. Closes molds. Carries out molds. Pours molds.

Item	DETAILED INSTRUCTIONS			Element Time per piece	Time for Entire Lot	Continuous or running Time
1	Molder cuts over sa. in own time. Riddle on h'k over y'k.					
2	(inconv., long reach), parting on bench to left. Peaner					
3	cope board & flask on bench to left. Bottom bds. ave					
4	4½ ft. away. Carry out 15 ft. Core sd. 5 ft. from mach					
5	Support on yoke for plate. Support on platen to assist					
6	in rolling over					
7						
8						
9	Piece mounted on steel plate					
10	Number of patterns per flask=8					
11	Wood snap flask. 14½ x 10½ — 3½ — 3.					
12	Weight of mold 54 lbs.					
13	Weights rolled over by molder:					
14	Item No. 5, sheet No. 2= 72 lbs					
15	Item No. 16, sheet No. 2=104 lbs					
16	Item No. 5, sheet No. 3=138 lbs					
17	Item No. 13, sheet No. 3=92 lbs					
18	Weight of flask, 26 lbs.					
19	Weight carried out by molder, 60 lbs.					
20	Weight of plate, 26 lbs.					
21	Weight of false plate, 20 lbs.					
22						
23						
24	(NO PREPARATION TIME ALLOWED)					
25						
26	Separate cope and drag			.01		
27	Clamp drag (1 clamp)			.03		
28	Put drag on platen			.03		
29	Put plate on drag			.03		
30	Sprinkle plate with parting			.05		
31	Put riddle on plate			.02		
32	Put handful core sand in riddle			.04		
33	Riddle			.04		
34	Put 1 shovel of sand in riddle			.05		
35	Riddle			.07		
36	Hang riddle on hook (on wall over yoke)			.01		
37	Tuck with hands			.08		
38	Strike off (must be done carefully)			.16		
39	Blow off and clean plate thoroughly			.15		
40	Put false plate in place			.07		
41	Clamp cope (1 clamp) includes moving to bench			.05		

(Continued on Page 117)

(*Continued from Page* 116)

42	Put cope on drag	.05	
43	Roll over, empty flask except for cheek	.04	
44	Sprinkle with parting	.04	
45	Put riddle on flask	.02	
46	Put 1 shovel sand in riddle	.05	
47	Riddle	.05	
48	Hang riddle on hook	.01	
49	Tuck with hands	.06	
50	Fill drag with sand (1 shovel)	.07	
51	Pean with Peaner	.16	
52	*Strike off and put bottom board in place	.14	
53	Rap board in place with peaner	.06	
54	Roll over	.08	
55	Sprinkle with parting	.05	
56	Put riddle on cope	.02	
57	Put 1 shovel sand in riddle	.05	
58	Riddle	.05	
59	Hang riddle on hook	.01	
60	Tuck with hands	.08	
61	Fill with sand (1 shovel)	.07	
62	Pean with peaner	.16	
63	Strike off, put cope board in place (carried on bh.)	.11	
64	Swing yoke forward	.02	
65	Push flask back	.02	
66	Squeeze	.05	
67	Swing yoke back	.01	
68	Remove cope board	.04	
69	Cut sprue (Cutter on yoke)	.05	
70	Blow off	.08	
71	Rap	.06	
72	Draw cope	.10	
73	Put cope on bench	.04	
74	Blow off plate	.05	
75	Draw false plate, put on floor	.04	
76	Sprinkle cheek with graphite	.11	
77	Blow off	.06	
78	Bring drag to cope	.04	
79	Close	.08	
80	Put cope board in place	.04	
81	Roll over	.07	
82	Draw drag	.04	
83	Put on bench	.04	
84	Draw plate	.06	
85	Put plate on yoke	.02	
86	Repair mold, per pc	.02	
87	Bring drag to cope	.04	
88	Close mold	.03	
89	Roll over	.07	
90	Remove cope board, put on bench	.03	
91	Unclamp flask	.02	
92	Remove flask, put on bench	.06	
93	Slick up mold	.12	
94	Carry out mold	.07	
95	Put on floor	.03	
96	Return to machine	.05	
97	Clean up round machine, time per mold	.02	
98	Clean plate, every 20 molds, time per mold	.02	
99	Clean pins, every 20 molds, time per mold	.01	
		4.03	
	20 per cent. handling time	.81	
		4.84	

* Includes picking up bottom board from pile 5 feet away.

WHEN WORK CANNOT BE DONE AS ORDERED GANG BOSS MUST AT ONCE REPORT TO MAN WHO SIGNED THIS CARD

Mon. Day Year

Signed
F. R. W.

Checked

FIG. 7—INSTRUCTION CARD FOR OPERATION ON A DIFFERENT PATTERN THAN THAT IN FIG. 6

other cases he does not owing perhaps to his being too pressed with work to take the time for writing an exhaustive paper, or he may feel that he does not possess the requisite literary ability to present the matter in a proper form. In other cases he may be deterred by disinclination to share with others the fruits of his labor.

This applies to those highly technical problems which the foundry art involves, and which today are matters of traditional knowledge and rule-of-thumb perhaps to a greater extent than in any other branch of engineering. To work out all of these problems in as complete and accurate a way as should be done so as to develop foundry practice into a true science is a far bigger undertaking than can be carried out by any single company.

The working out of a proper system for the application of scientific management to the foundry industry is another tremendous problem, and the research work connected with making complete time studies of molding would involve an expenditure of time and money which would be a heavy burden for any single company, and it would seem almost a wicked waste for a great number of different companies to be obliged each to duplicate a large part of the work done by the others.

Establishment of an Experimental Foundry

If the expense of work of this character were to be divided on a proper basis among the members of this Society who might profit thereby, the burden on any one would be very light indeed. If the Society were to undertake the working out of this problem, establishing for the purpose a special foundry in which all experiments might be made, a proper system of management worked out in all of its details, and complete elementary time studies on all classes of molding made, it would be serving its members to a far greater extent than would be possible in any other way.

Such a foundry might also be used as a training school, not only for molders, but for foremen and superintendents.

Owing to the fact that the foundry business is competitive only in a very limited degree this would be possible, whereas in certain other industries such a plan would be out of the question.

Progress in the foundry art would under such a scheme be much more definite, much more rapid and infinitely less costly than it has been under existing conditions and still is, and this Society would be placing itself on a plane of usefulness far beyond that achieved so far by any other similar body.

It might be pointed out that the expense to be borne by the members would be reduced through the fact that such an experimental plant or laboratory as has been described would naturally have to be operated, in order to secure the best results, on a productive basis, and while it should not be expected to earn profits its income would at least bear a large part of the cost.

In presenting this plan, which I regard as the most important part of my paper, I hope I may prove to have rendered a service to your association.

Discussion

MR. H. K. HATHAWAY:—Since I prepared this paper, I have heard a few things that I was not aware of at the time I wrote it, and I may have to modify one or two of the statements I made therein. One is in respect to the paper read this morning in reference to the work done at the University of Illinois, and I could not help but notice then that the knowledge of scientific management is filtering its way into the foundry industry, and it seems quite remarkable that it should be finding its way into the foundry by way of the college.

THE CHAIRMAN, MR. R. A. BULL:—Mr. Hathaway's paper, which I hope you will all read thoroughly, is a most interesting one, and it is unfortunate that it is absolutely necessary

that we abstract the papers for oral presentation, because if we don't, we won't have time for any discussion. A great many times the discussions are the milk in the cocoanut. The final recommendation or suggestion that Mr. Hathaway makes concerning the experimental foundry is a most interesting one, and I would be very glad for someone to open the discussion on that phase of the paper. Possibly it strikes you, gentlemen, like it did me when I read it, that it needs some pretty careful reflection and it is a matter about which we should not frame any opinion without mature judgment. It is a constructive suggestion, however, and there is a great deal that will give us cause for serious study.

Organization in the Foundry of the University of Illinois Shop Laboratories

By R. E. KENNEDY and J. H. HOGUE, Urbana, Ill.

During the last few years there has been much discussion among the employers of technical graduates and those men who are at the head of the administration of the technical courses in the colleges and universities, as to the value of the training in shop practice given to the undergraduate student.

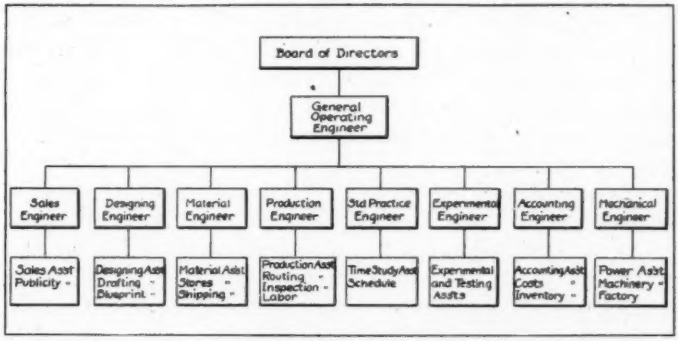

FIG. 1—OUTLINE OF THE OPERATING ORGANIZATION OF THE SHOP LABORATORIES

The Specialization of the Executive Work is as Necessary in Any Manufacturing Plant as the Specialization of the Duties of the Workman

The purpose of these courses, when first started almost 40 years ago, was to give the college course an air of practicalness and afford the student some training in the elementary principles of shop work. Very few of the students entering the technical schools then had any acquaintance with shop principles and methods of manufacture, and it was necessary first to instill in their minds a knowledge of the elementary shop practices.

Because of the recent advance in trade and manual training teaching in the secondary schools, and the changing demand

of the employers of technical graduates, the question as to the advisability of changing, or entirely abandoning the work has arisen, and it has become a vital problem to the schools concerned.

The question was aptly stated by Dr. W. F. M. Goss, past president of the American Society of Mechanical Engineers, when he said "The time has come when the shop laboratory should cease to be content with a grade of work possible in a secondary school; its work should possess a quality and character which is only possible in the environment of the technical school. This implies that the work of the shop laboratories must be interrelated with that of other technical courses, that such laboratories must cease to use equipment which was purchased one or two decades ago, and that they must cease to be satisfied with methods of administration which, in actual shops, have already passed out of existence. If the shops are to mean anything worth while, they must not only respond to the great and significant changes which have been going on outside, but they must have their part in leading such changes. Their work must not stop with the routine; it must proceed to the development of research that new principles may be established."

With this problem before them, those in charge of the shop work at the University of Illinois set about reorganizing the work and putting it on a basis where the student would derive the greatest benefit. Thus, not merely to develop skill in hand manipulation, but to develop those qualities needed in the executive rather than those needed by the molder, was the problem to be solved.

To do this, the nature of the work had to be changed from mere teaching of manual training to instructional work showing the principles of modern shop organization.

Reorganization on a Commercial Basis

As the main object of the whole course in shop laboratory work is to teach the engineering students the principles of shop organization, the foundry and other departments of the shop laboratories were reorganized on a commercial basis. A num-

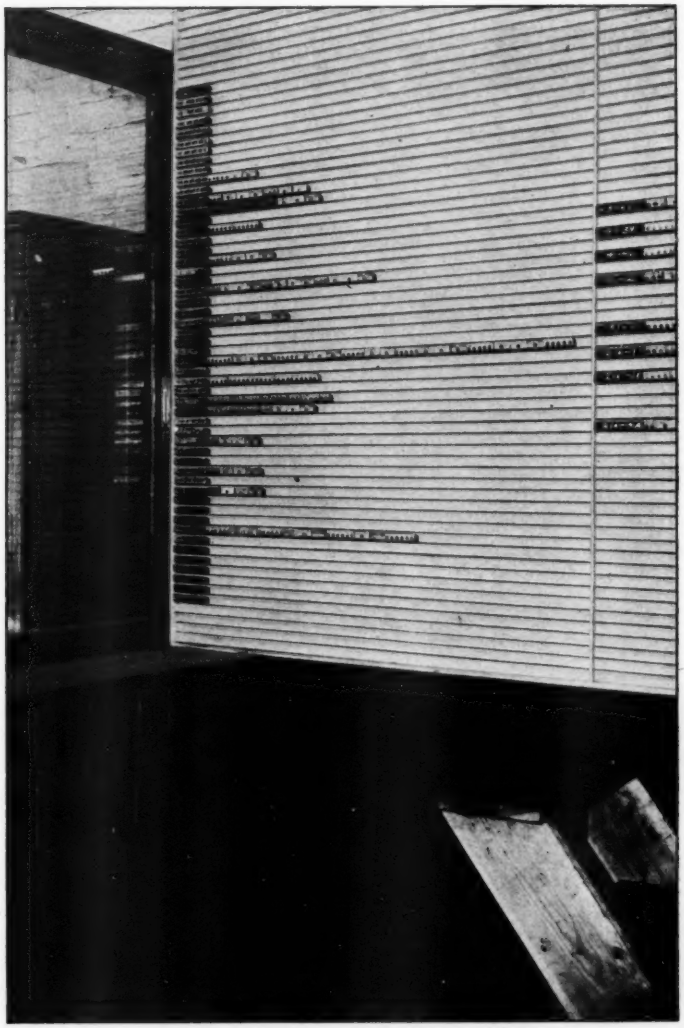

FIG. 2—WORK SCHEDULE BOARD

The Staff Assistant's Office Should be a Place Where is Gathered All the Information Needed For the Planning of Work and Scheduling Its Progress Through the Shop.

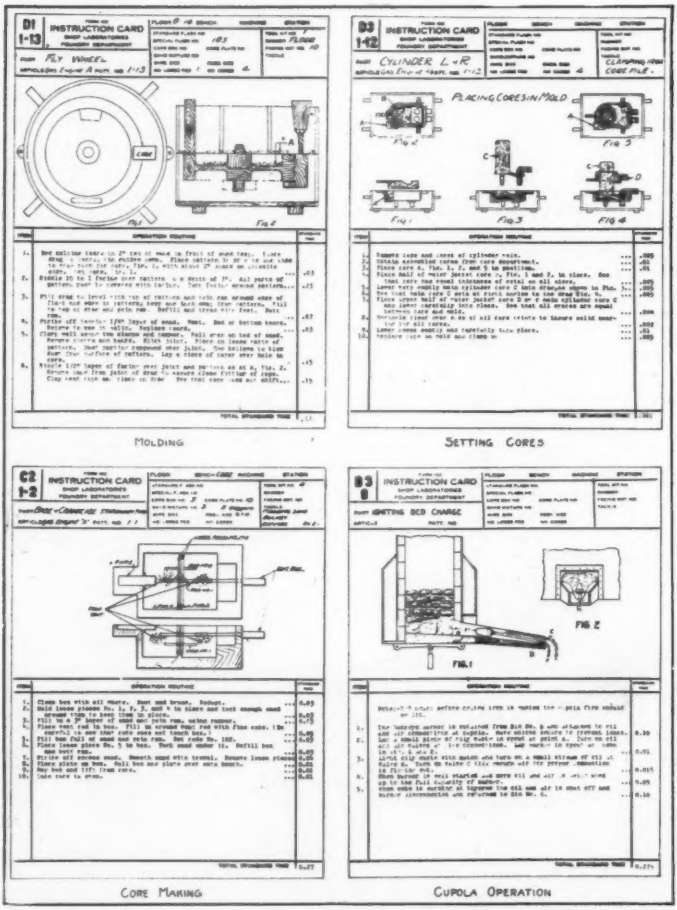

FIG. 3—THE INSTRUCTION CARDS SHOW HOW THE WORK IS TO BE PERFORMED

ber of standard products were adopted for regular manufacture, among which was a two-cylinder, eight horsepower gasoline engine. This engine was the first product developed and standardized.

FORM 7
UNIVERSITY OF ILLINOIS
SHOP LABORATORIES

RECORD OF TIME STUDY

DEPT._____

OPERATION Core Making
ARTICLE Piston Pattern 1 - 24
INSTRUCTION CARD NO. C 1. 1 - 24 OPER NO 1
OPERATOR'S NAME Sundell, H. A. NO. 24 SEC A
DATE 9/5 1914 TIME STUDY NO. 2

ITEM	DETAILS OF OPERATION	TIME ACTUAL	TIME LOST	TIME PROPOSED	EXPLANATION OF OPERATING TIME LOSSES
1	Placing plate on bench	.03	.02	.01	Could not locate right plate at once
2	Cleaning box	.04	.03	.01	Had been using sand too wet.
3	Place box in position. Assemble	.01		.01	
4	Ram first layer of sand. Set rods.	.05	.04	.01	Rods cut too long. Had to exchange
5	Set 2 loose pieces of box	.01		.01	
6	Fill box and ram. Strike off.	.04		.04	
7	Remove loose pieces. Fill with molding sand	.02	.02		Use of iron dryers would eliminate this item
8	Clamp box. Roll box over on plate	.02	.01	.01	Clamps loose
9	Rap box, and lift	.01		.01	
10	Patching torn corner	.04	.04	.00	Box needs repairing. Send to pattern shop.
11	Blackening	.05	.02	.03	Core maker used a very small brush
12	Carrying to oven	.07	.05	.02	Had to wait for helper
	TOTALS	.39	.23	.16	

INVESTIGATED BY _____ WORK SCHEDULE ENGINEER
STUDY MADE BY: Pope, G. H. WORK SCHEDULE ASSISTANT

FIG. 4—RECORD OF TIME STUDY

A Time Study of a Simple Operation Often Brings to Light Many Things to be Corrected in the Shop Practice. A Well-made Study and Careful Analysis of the Results is One of the Most Beneficial Features Developed by Scientific Management Theories

Orders are issued from the director's office for the erecting of a given number of engines and each department receives its individual order for the parts which it must manufacture.

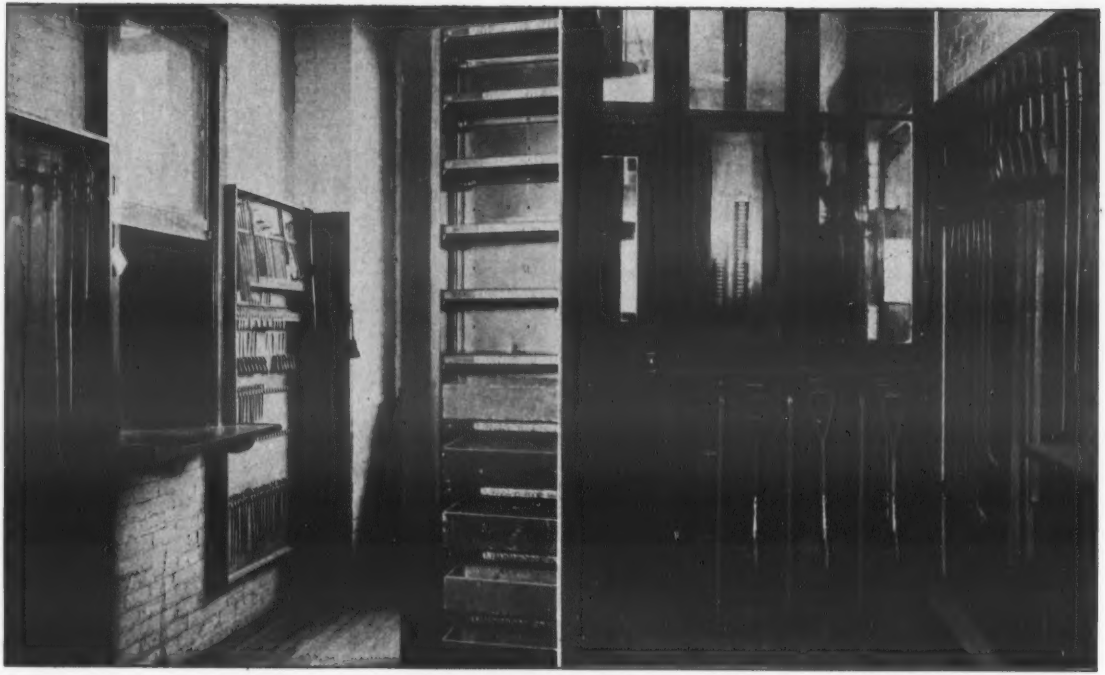

FIG. 5—A TOOL ROOM FROM WHICH THE WORKMEN CAN OBTAIN THE RIGHT TOOL WHEN NEEDED IS A PAYING INVESTMENT FOR ANY PLANT

The method of instruction pursued in the departments of the shop laboratories necessary to carry out this plan can be explained by describing the work as followed in the foundry, with a description of the foundry mechanical equipment. All departments, machine, pattern, forge and foundry, are working on the same general plan, although each has its own distinct problems of production, mechanical efficiency and organization.

Preliminary Instructions

The preliminary work of instruction in foundry work is covered by a series of demonstrations and lectures on the

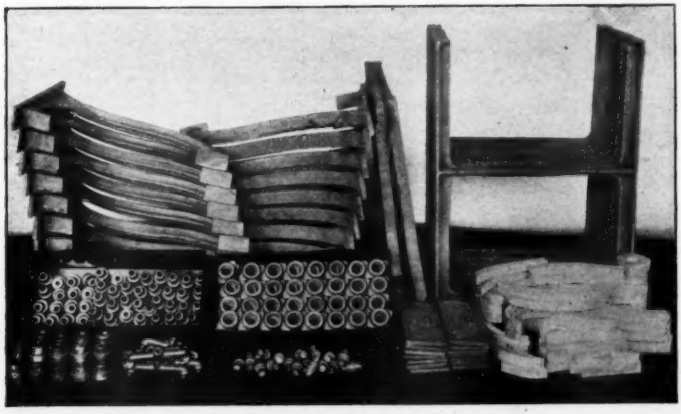

FIG. 6—SMALL IRON, BRASS AND ALUMINUM CASTINGS MADE BY STUDENTS DURING THEIR FIRST WEEK'S SHOP WORK

essential features of bench and floor molding, coremaking and cupola practice. Immediately after a demonstration of one feature of the work has been made, the students are given some time in which to do the actual work and thus fix the method firmly in their minds.

It has proven to be a fact that the more time spent in demonstration, while reducing the actual working time of the student, has resulted in an increase in the production of castings.

In addition to the reading of notes on foundry practice, the students subscribe to one of the leading foundry magazines and study the articles and advertisements. This gives them an insight into the methods used in the most modern shops and makes them familiar with the problems foundrymen are encountering in their work.

Organization of Shop Forces

These demonstrations and practice periods so cover the work that when they have been completed, the students can be organized into shop forces, and with the proper supervision carry on the work of a producing foundry.

With this organization, the students are divided into two general groups:

1.—Staff assistants or executives.
2.—Producing force.

The staff assistants are six in number:

A.—Production.
B.—Materials.
C.—Mechanical.
D.—Standard practice.
E.—Accounting.
F.—Experimental.

The producing force is divided into the usual groups of

A.—Molders.
B.—Coremakers.
C.—Cupola operators.
D.—Cleaning force.

The general plan and relation of the functions performed by the staff assistants can be noted in the chart, Fig. 1. To show the work accomplished, the duties of each assistant will be considered in detail.

Production Assistant

The production assistant has charge of shop production, including the working forces and shop equipment. He is responsible for shop output.

As the orders for castings are received, he enters these on his production sheet and announces the schedule for producing these castings. He issues the necessary work orders in their proper order; that is, he first orders the preparing of the material for cores, if cores are to be used, then when this is

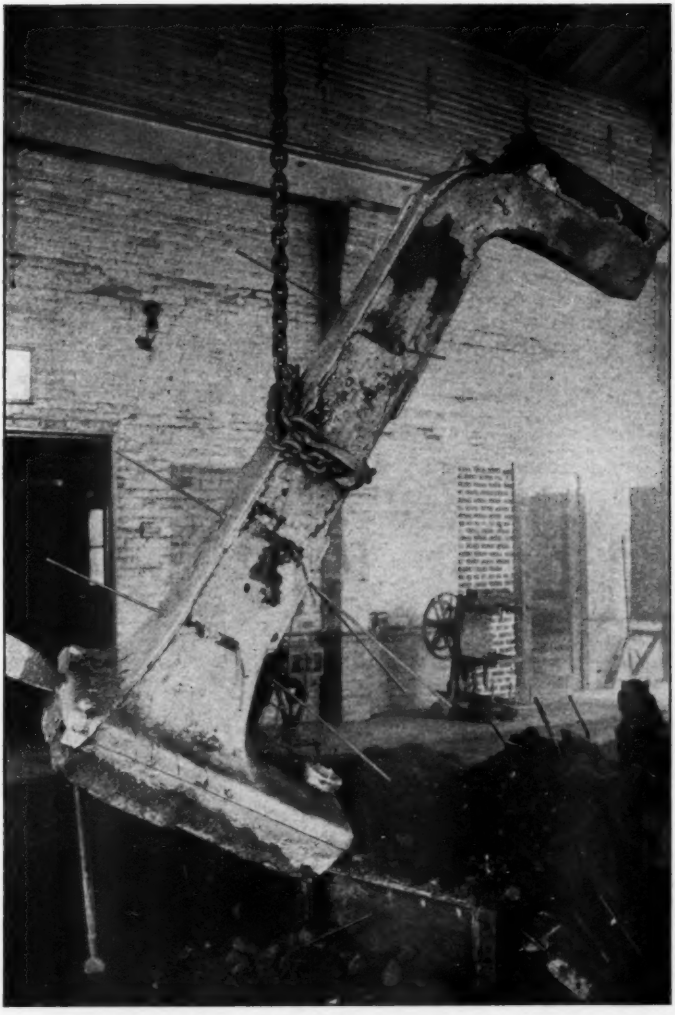

FIG. 7—WOOD MILLING MACHINE COLUMN CASTING, SHOWING THE VARIATION OF WORK IN THE SHOP LABORATORIES

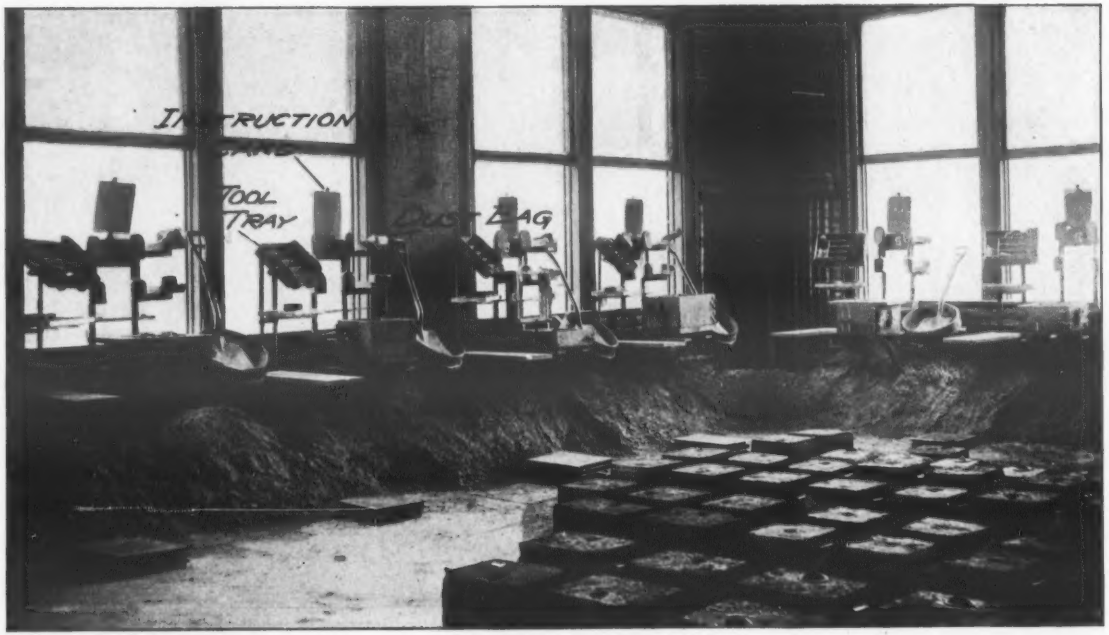

FIG. 8—MUCH CAN BE DONE BY MOLDERS TO SO ARRANGE THEIR TOOLS THAT A MINIMUM AMOUNT OF TIME NEED BE SPENT IN REACHING AND PLACING THEM

ready, he issues the orders for making the cores. When the cores are on the stock shelves, the work order to the molder is issued. A work schedule board, Fig. 2, has been placed in the office of the production assistant on which is kept a record of the progress of the work. The work posted on this board is that which should be turned out in one week.

All foundry operations on regular products are standardized and definite instructions are issued in the form of instruction cards, Fig. 3, for the making of each core, core wire, mold, the mixing of core sand and cupola work. These cards contain all the necessary information relative to the production of that piece of work. In the case of a mold, it has the size of flask to be used, the tools needed, the cores used, the place where it is to be worked, an operation routine, and a standard time, which is the time in which the piece should be made if no waste effort occurs. This work of making instruction cards is performed by students, in the manner described later under the heading of *Standard Practice Assistant.*

With this detailed information, the production assistant knows in what order the work should be made and how long it should take. The progress board, when filled out, then is before the assistant as a picture of the way his work is being performed. For each pattern to be used there is placed in the grooves of the board a block on which the pattern number is stamped. Other blocks which indicate the different core and molding operations are placed in the same groove. As the cores are made, this information is sent to the production office and colored tacks are placed in the blocks which indicate the state of work on that particular operation.

With the information of this board before him, the production assistant can intelligently issue work orders for the making of molds and cores.

He then gives to the materials and mechanical assistants the information as to when and where these cores or molds are to be made and they oversee the preparation so that when the molder or coremaker receives his work order card, he proceeds to the assigned place and finds everything in readiness for the production of the cores or molds, so that he can devote his whole energy to the actual work of coremaking or molding.

As the castings are poured, sent to the cleaning room and then delivered, this information is recorded on the board so that the production assistant can at all times tell the stage of progress of each casting.

This information is brought to the production office by the inspector who keeps track of the cores and molds made and of the good and bad castings poured, cleaned and delivered.

The production assistant also has charge of the operation of the cupola and cleaning of castings, shifting his forces around to suit the needs of the work to be done.

The standardization of such work as mixing core sands and cupola preparations, has proven to be an important factor of success in this work of getting good product from comparatively inexperienced workmen. This same principle of standardization of materials could be employed to great advantage by many foundries which are at present doing the work by the old *hit-or-miss method*.

The workmen, having finished their task, stamp-out on their work order cards and are given another work order, and when they proceed to this work they should find their materials and tools waiting for them.

This method of work forcibly impresses on the student the benefits to be derived from a well-defined plan of knowing how the work is to be done, where it is to be made and when, showing the difference between planning the work in advance and attacking the same without consideration as to methods to be used.

The production assistant, during the time he is holding that position, makes notes of all conditions of shop operation or methods coming under his supervision, which may be changed or eliminated, thereby increasing the efficiency of the shop or bettering the quality of the work. From these notes, he writes a report on conditions and gives his recommendations for improvements.

These reports are discussed and it is considered that the training derived from the making and discussion of them is one of the most beneficial results of the work in the shop laboratories.

The Material Assistant performs the duties as outlined on the chart, Fig. 1. These duties, in detail, include the keeping of inventory records of materials, which outline the maximum and minimum quantities of materials to be kept on hand for use

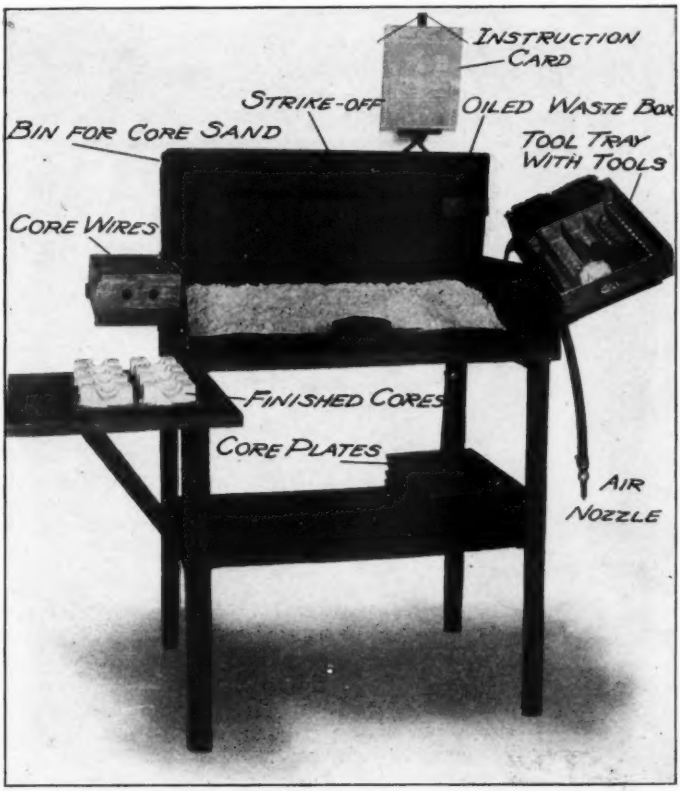

FIG. 9—THIS CORE BENCH ARRANGEMENT ALLOWS THE CORE-MAKERS TO TURN OUT A LARGE AMOUNT OF WORK IN THE GIVEN SPACE OF TIME

in the foundry. By the use of the record sheet, the assistant, at any time, has a knowledge of the amount of stock on hand, and when this stock is reduced to the minimum quantity, he orders a new supply.

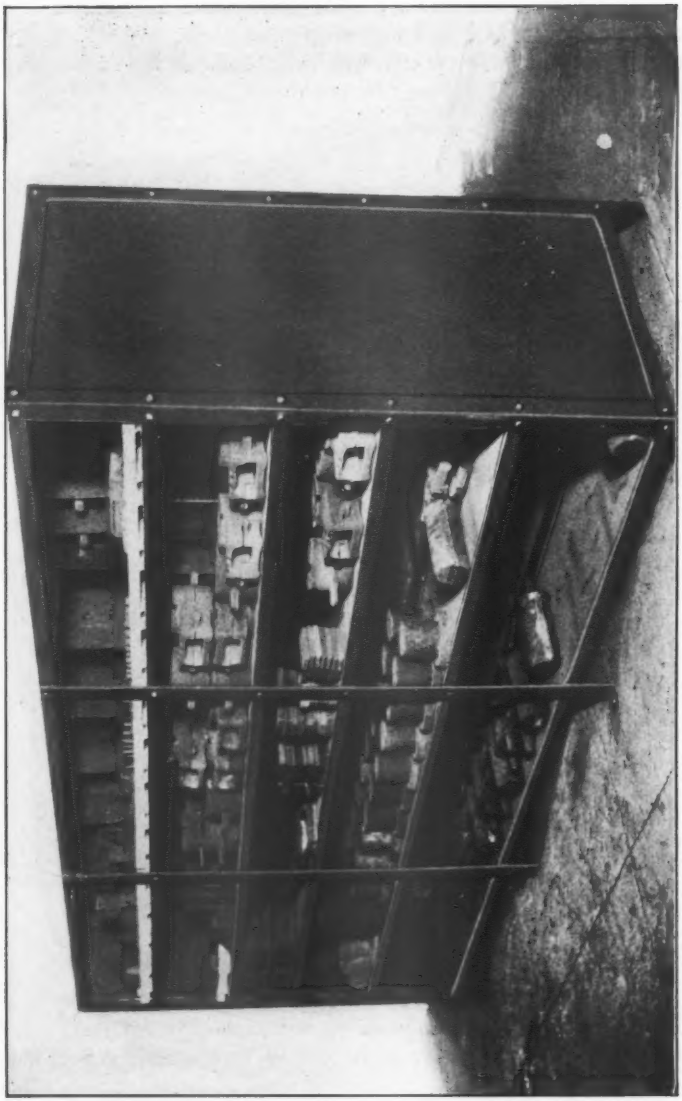

FIG. 10—CORE RACK WHERE THE SETS OF CORES ARE ASSEMBLED FOR THE MOLDERS

In ordering he obtains his information as to specifications from the record sheet on which is outlined the place of purchase, analysis or quality, etc.

From the production assistant the materials assistant receives a record of the molds and cores to be made, where they are to be made and when. With this information in hand, it is his duty to see that the molders have all their supplies brought to them, such as cores, graphite, parting compound, nails, etc. He has charge of the mixing of the core sands, cutting of core wires and rods and these he supplies to the coremakers when needed. The instruction cards indicate the kind of core sand needed for each core and these sands are mixed according to the standard prepared, eliminating the usual guessing as to the amounts of sand, binder and water.

The materials assistant's work puts before the student the importance of knowing the amount of stock on hand, the danger of having materials out of stock, the loss in money to the plant when keeping in stock such large supplies of certain materials because the information as to the amount used in a given period of time is not known.

Mechanical Assistant

The duties of the mechanical assistant consist of the maintenance, in an efficient condition, of all shop tools, machinery and equipment. He has charge of the tool room and its attendant, overseeing the care of the tools kept in this tool room.

He has on record a list of all tools, with the condition in which each tool must be kept to be efficient. This record is called the tool standard and tells when to repair or to discard and replace tools.

It is his duty to oversee the oiling of machinery, repairing broken parts, or recommending the purchase of new equipment. The flask upkeep comes under his supervision and he sees that the flasks and boards are repaired or replaced.

Similar to the materials assistant, the mechanical assistant receives the notice of molds and cores to be made and he prepares the tools and mechanical equipment needed. It is his duty to keep the molders supplied with the right flasks, boards

and tools. The coremaker is furnished with the plates needed and necessary tools for the job to be worked.

For the mechanical assistant to know what tools are needed, he must consult the instruction card, on which is recorded all tools, size and kind of flask, plates, or machines needed for the work.

By the co-operation of these three assistants, the work is all planned in advance, eliminating the trouble so often encountered, when, without planning, a job is started, and then an endless succession of delays are met with and consequent loss of several men's time while waiting for flasks to be brought in, cores to be hunted, tools needed but not to be found, and many more difficulties of the same kind.

This brings to the students' attention the value of planning and preparation in a real, practical demonstration. They see, when they do not perform their part, the consequent loss of time of the other men and the result is more thoroughly impressed on their minds than by any other method.

Standard Practice Assistant

The work of the standard practice assistant, as the title indicates, involves the work of standardizing the shop practices, the method of operation routines and the materials and tools used.

To obtain standards on core sands, facing mixtures and cupola relining mixtures, the students make a study of the qualities of different mixtures, comparing their qualities with each other. The proportions of binder and sand, the amounts of water, the routine of mixing and time of baking are recorded.

In this manner the best core sand mixtures for the various types of cores are found. This information is then recorded on an instruction card and when this mixture is needed the card is used by the materials assistant in preparing this sand for the coremakers.

The standard operation routines and times set on the instruction cards of the types shown in Fig. 3, are obtained by making a detailed time and motion study analysis of different men working on the same piece of work. Care is taken to

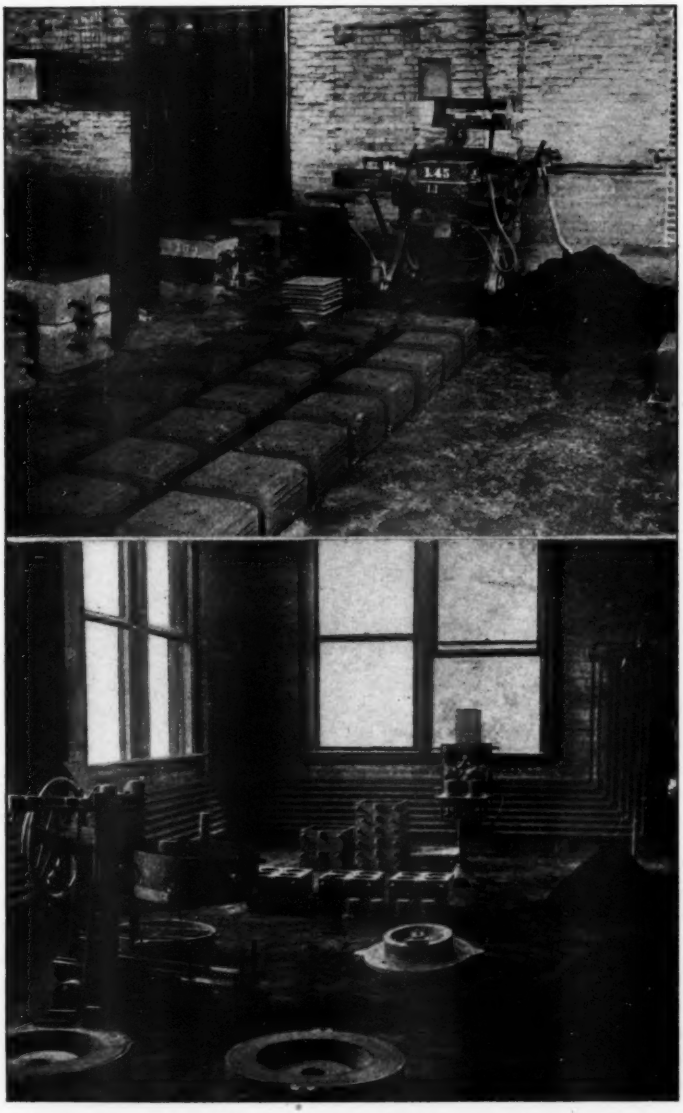

FIG. 11—THE ADVANTAGES TO BE GAINED BY THE USE OF THE DIFFERENT TYPES OF MOLDING MACHINES ARE TAUGHT TO THE ENGINEERING STUDENTS

study the job to discover the best operation routine and the time needed to perform the necessary routine items, while the necessary tools and materials are listed.

The studies being completed, any helpful sketch is placed on the card, the operation routine written and then blue prints are made from the tracing. The prints are pasted on heavy cards and filed away in the staff assistant's office to be issued as needed by the workmen.

This is the treatment for all standard work. For miscellaneous work, a temporary instruction card is written, giving the estimated time, and other information required, such as position of gates, venting, setting of cores, etc.

Therefore, a finished instruction card not only tells the workman how to do a piece of work, but it gives the assistants the information necessary to prepare all tools and materials and it tells the production assistant how long a given piece of work should take and the order of operation routine.

This work of investigation and time study has proven to be of more value to the students than any other work they perform, as they find that because certain work has always been performed in a certain way in the past is no reason why it should continue to be made that way. The student is always keeping before himself the idea that probably there is a better way of doing the work and it is up to him to make the most thorough study possible to determine the most efficient way. This is training the student to think and analyze conditions for himself.

Experimental Assistants

Due to the nature of manufacturing work there are always new mechanical problems to be investigated and solved. These are slowly solved in ordinary plants by men whose time is supposed to be spent in the regular work of production. The best equipped and most modern concerns have specially trained men in a separate department whose sole duty it is to investigate and test new methods, machines and materials.

The foundry has an unlimited number of such problems and the experimental assistants are given lectures on some of these possibilities, and are then set to work on particular problems relating to this shop. Experiments and tests are made by

the students on such subjects as metal mixtures for brass and iron castings, cupola refractories, core sand binders and sands, and on labor saving machines. By carefully analyzing the results of the tests and recording the data obtained, much benefit is gained in the performance of this work.

The work of the accounting assistant includes the care of the inventory records, recording the labor and materials cost on the different orders, and assigning overhead charges to these orders.

FIG. 12—BRASS FURNACE AND FLOOR OF BRASS MOLDS

He obtains the labor cost from the work order cards, and the materials cost from the information records of the materials assistant.

All the staff assistants make a report on the conditions that come under their observation, which they think can be bettered and their methods for the accomplishment of these changes are set forth in this report.

While the introduction of shop management principles is the main object of the work, the use of a well planned layout of shop equipment has been emphasized and many novel features

have been worked out, which could be installed with profit by many shops.

A need was felt for a well-equipped tool room in which to store the small tools, commonly used in a foundry. One of the greatest sources of lost time in foundry operation is caused by the workman not having the proper tool and he either does the work with a less efficient tool, or if the proper tool is supposed to be around, he will spend a long time hunting it. The workman will seldom supply himself with a full set of tools, because some are needed so seldom that he thinks he can get along without them. But there are times when he needs one or more of these and he does not have them. This tool room, shown in Fig. 5, also provides a storage place for riddles, rammers and shovels, which, as a general rule, have to stand all kind of abuse because no definite storage place is provided.

The tool trays stored in the tool room are filled with sets of tools called for on the instruction cards and these are set on the molding and core benches as shown in Figs. 8 and 9. Odd tools are checked out by the workmen on the ordinary brass check system. When these tools are returned they are inspected by the tool room attendant, and any needing repair or replacing are set aside and turned over to the mechanical assistant.

Two of the biggest labor-saving devices designed and put into use in this shop are the molding and core benches shown in Figs. 8 and 9. These benches were designed with a view of having a place for every necessary tool and all materials, and to have each thing within the easiest reaching distance, and a most convenient place for replacing.

By this arrangement and the following of the standard operation routines, practically all of the waste or lost effort, so common in bench molding and coremaking, is eliminated.

The utility of this molding bench was pointed out in a paper presented by the authors before this association at its meeting in 1914.

The principle of the arrangement of the core benches, Fig. 9, is similar to the molding benches. The hopper holds a large quantity of sand, thus allowing a large amount to be

delivered to the bench at one time and yet to prevent it from being spread out in the way of the workman. The standard tool tray is placed at the right for convenience in reaching the tools. Being tilted, the tools can be easily seen and reached. At the left is the wire and rod box, off the working surface of the bench, yet easily reached.

These boxes of bent wires are brought from the stock room as ordered by the materials assistant. The empty plates are stacked on the lower shelf of the bench, while the small side shelf is used on which to set the core plate when being filled.

For cleaning the core boxes there is a waste holder for holding the kerosene-soaked waste with which to clean the box, and a compressed air hose with an attached blow gun for blowing out the dirt. The strike-off has its holder on the sand hopper directly in front of the worker, easy of access and can be replaced by throwing it into place. The instruction card holder is so placed that the card can be easily read by the worker.

By this arrangement of the bench, the coremaker has and keeps each thing in its place and loses no time in hunting for the tools, plate or wires needed. His whole time, for this reason, can be devoted to doing the actual productive work of coremaking.

Ovens and Core Storage

The oven equipment consists of one large truck oven, heated with an oil burner, and one portable, gas-fired oven. When the small cores are taken out of the oven they are set on the nearby cooling shelves of the rack, shown in Fig. 10. The upper shelves are devoted to stock core storage. As the orders are made up for the different molders, the cores are placed on trays, shown on the molding benches, Fig. 8, and are taken by the materials assistant to the molding benches or floors when they are to be used.

Some of the machines in use are shown in Fig. 11. The greater percentage of the standard patterns are fitted up for squeezer machine work, although the flywheels, pistons and similar work, are made on the stripping plate and roll-over machines.

The melting equipment consists of two Whiting cupolas and a Hawley-Schwartz brass furnace. A 5-ton Whiting crane commands the entire molding floor space. Figs. 6 and 7 show some of the large and small work which can be turned out by the students after a short period of instruction if the work is administered in the most efficient way.

The ideal of the instructional work is to convey to the student a knowledge of the best methods of foundry practice, to give him the ability to distinguish between good and bad practice, and to instill in his mind the methods used to investigate shop performances.

Discussion

MR. O. J. ABELL:—It seems to me that one cannot help being impressed with these pictures, particularly if one has had the opportunity of visiting such schools as the University of Illinois. Even to those who have been out of college only a short time, the tremendous advance that has been made in making the instruction in the laboratories of technical schools and universities more practical is notable. I can well remember what the criticism of academic instruction in schools has been. The question whether all of the time spent in the technical schools ought to be given to studies in the class room as against provision for experiments in the laboratory will always have advocates on both sides, but those who believe in laboratory work and the making of it more practical and more closely approaching conditions in the commercial shop, will see in this paper occasion for congratulation.

THE CHAIRMAN, MR. R. A. BULL:—I think the statement can be made without reservation that all of the technical schools court the co-operation of people like ourselves. I am sure that Mr. Kennedy would endorse that statement so far as his institution is concerned, and we will do well, for ourselves and for those educational institutions that are reasonably close to us, if we show some interest in the work they are doing and give them the benefit of our advice and suggestions which they are always very glad to receive.

A Preliminary Report on Molding Sands

By C. P. Karr, Washington, D. C.

What is a good molding sand? How may it be distinguished from a poor one? How may it be tested?

It seemed worth while to the advisory committee on non-ferrous metals of the American Institute of Metals and to the Bureau of Standards to undertake to answer these questions in a systematic way, and the experiments here described are the preliminary results obtained with the co-operation of that committee and of the firms which have kindly furnished the materials on which the tests are based.

A sand, at the same time, may be both a good and a bad molding sand. The purpose for which it is to be used must be taken into consideration before a decision can be made.

In non-ferrous metals and their alloys a heavy casting should be cast in a coarse sand, of a high degree of refractoriness and a fairly high degree of permeability, and at the same time it should possess more than an average transverse strength to bear the burden of the molten metal until freezing ensues. Fine castings require a finer grade of sand, one that will retain sharp edges and fine lines, and at the same time will have a good degree of permeability, but which may have an inferior transverse strength and a lower melting point than is required for heavy castings.

For heavy castings of ferrous metals and their alloys, a higher degree of refractoriness and a somewhat greater transverse strength is required, and a greater percentage of clay may be tolerated than in non-ferrous castings of a similar grade. For light iron castings a finer grade of sand is required in order to retain sharp edges and fine lines; the transverse strength may be low, and the permeability may be lower than for a similar

class of castings in non-ferrous work, because in the pouring of iron and its alloys not so much gas is given off as from the copper alloys.

Porosity and Permeability of Sand

All molding sands must have sufficient clay to enable them to be molded into shape, to retain sharp edges and fairly fine lines, but not enough to make the mold shrink and crack under sudden, intense heat. Molding sands must be porous and permeable. Porosity of a sand, as received from the manufacturer is of less importance than its permeability. A sample of sand, as observed by Mr. Searles[1], may be very porous when placed in a test tube or cup, but it may be entirely unsuitable for molding, because when rammed to form a mold, the gases driven into it cannot escape.

By porosity is meant the volume of pore space between the grains. It depends mostly upon the size of the grains and the relative proportions of the various sizes. If the bond of a sand, in its natural state, be dependent upon the presence of organic matter, the sand will become more porous after it is subjected to a pouring heat, but if its natural bond is due to clayey material it will tend to become less porous at a high temperature as a result of the baking, sintering or fusing of the clay.

By permeability is meant the property of allowing liquids or gases to flow through the sand, and this property depends upon the size of the pores. A sand may contain a few large openings through which liquids or gases may readily escape and yet have a small total pore space. The total pore space might be large, but if the size of the pores were small the permeability to either gases or liquids would be small. Clay not only decreases the porosity of sand but tends to close the spaces between the larger grains and renders the sand less permeable and more plastic.

If the components of a sand are fusible enough to agglomerate when exposed to the heat of the molten metal, the natural

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[1]*Engineering Magazine*, October, 1912, p. 103.

openings in the sand are closed and the gases carried down by the metal find no outlets for escape and thus have a tendency to produce porous castings.

Such a sand would be deficient in refractoriness. Steel castings require a high percentage of silica in the sand, some of them as high as 97 per cent SiO_2, but, of course, need some clay as a binder. Sand for iron castings need not be so refractory, and 70 to 80 per cent SiO_2 would be sufficient.

Refractory Sand

A refractory sand may be pure silica, or it may contain an appreciable quantity of alumina, iron oxide, lime, magnesia, and alkalis, but any or all of these minerals except alumina have a tendency to reduce the melting point of the silica sand, although the melting point is not directly proportional to the quantity of fluxes present.

The fineness of a sand is a property of great importance; it is a measure of the texture of the sand, and is determined by noting the percentage of each sample retained on sieves of different mesh. Parmelee's[2] experiments showed that there appeared to be no direct relation between the average fineness and tensile strength. The fineness of a sand, when used alone, determines its suitability for various kinds of casting, both as to surface finish and required degree of soundness.

The tenacity of a sand is dependent chiefly on the amount of clay and moisture contained and the uniformity of their distribution throughout the mass of the sand; other conditions being equal, of two sands, the one having the finer texture would be more cohesive than one of a coarse texture. When a sand has been used for some time and the clay has been baked dry so as to expel all the water of hydration, the sand loses its bonding power to some extent. To replace this bonding power organic substance such as molasses, flour and oil are introduced; but wherever sand so treated comes into contact with the

[2]N. J. Geological Survey, Annual Report, 1904.

molten metal its cohesiveness or bonding power is destroyed, and a certain amount of renewal of this treatment must take place before the sand can be used again to advantage.

Cohesiveness of Sand

The cohesiveness of a sand depends upon its power to resist the dehydration of the clayey particles of the sand and the alteration of its texture by heat. In some cases, especially

Table I

MECHANICAL ANALYSIS

Sieve No.	Size of opening, inches.	Laboratory numbers 5503	5504	5505	5506	5846
		Per cent retained				
20	0.0328	0.13	0.07	0.09	0.23	0.50
28	0.0232	0.14	0.82	0.11	0.34	1.45
35	0.0164	0.07	8.11	0.13	0.42	0.95
48	0.0116	0.22	16.94	0.28	0.60	1.00
65	0.0082	0.54	15.11	0.45	0.82	1.02
100	0.0058	4.58	20.62	1.51	5.19	3.15
150	0.0041	24.57	22.04	2.40	16.88	14.70
200	0.0029	22.02	7.83	12.26	16.54	15.50
Residue through 200...		22.90	4.82	....	23.36	38.00
Clay		23.40	2.00	82.06	34.00	22.54
Loss		1.33	1.64	0.92	1.70	1.00
Melting point, deg. C.		1,470	1,650	1,430	1,450	1,420
Average fineness, per cent—(Note 2)		86.5	90.5	31.0	65.3	58.8
		min. sec.	sec.	min. sec.	min.	min. sec.
*Permeability		2 40	54	5 5	2	4 51
Transverse tests, lbs...		1.43	0.39	2.59	1.49	1.87

*(Time of passage of 100cc of water through 97.37cc of sand.)

Note—Clay was removed by agitating for one hour, then decanting.

Laboratory Nos. 5503—No. 000 Crescent Albany sand, J. W. Paxson Co.
5504—No. 5 green core sand, Portage Silica Co.
5505—No. 0 Albany molding sand, Whitehead Bros. Co.
5506—"Finest Albany Sand" for brass, J. W. Paxson Co.
5846—Tub sand, composed of No. 2 Albany sand, 000 Crescent and small portion of Ottawa sand; Bureau of Standards.

Note 2.—The average fineness of a sand is obtained by multiplying the total amount of sand retained on each sieve by the number of each sieve and dividing that amount by 100.

in iron or steel molding, the heat may be sufficient to cause some or many of the grains to agglomerate by fusion, thus altering the texture.

For example, the sand marked 5846 in Table I, which has been in use for a year, for illustration of this point may be regarded as lacking in cohesiveness, as shown by low transverse strength and sand No. 5506 as a cohesive sand of nearly a similar character, but if comparison is made as to the amount

of sand retained on all the sieves from 100 down to 20 mesh, it will be noted that No. 5506 has particles of a larger size than the other, which in connection with its greater porosity might form an agglomeration of the particles. There is a greater shrinkage in the clay content and an increase in the residues which passed through the 200 mesh sieve.

A good molding sand cannot readily be distinguished from a poor one by the unaided eye, nor by one or two simple tests. It must be submitted to several tests, which when compared and the results correctly correlated and interpreted will enable one to distinguish between them.

A good molding sand has the following properties that satisfy the working conditions of good foundry practice:

1.—Texture or fineness of grain suitable for the kind of castings which are to be made in it.
2.—Cohesiveness or good bonding power.
3.—Refractoriness or resistance to the destructive action of the heat of the metal poured into it.
4.—Permeability or sufficient porosity to permit the escape of gases given off during the cooling of the metal.
5.—Durability to permit the sand to be used over and over again.

A molding sand may be tested:

First, for its texture by some adequate system of mechanical analysis.

Second, its cohesiveness may be tested by the tensile strength test, but the results, in all cases, do not appear to be satisfactory. Some measure of the property of cohesiveness may be obtained by a transverse test of the sand.

Third, refractoriness may be indicated by the melting point test.

Fourth, permeability may be ascertained by King's[3] aspirator test. He showed that the finer grained sands have a larger pore space than the coarse grained sands, even though composed of grains of approximately equal size, and that if the grains are angular, the pore space for any given size is increased, because angular particles will not pack so well. The minimum pore space was obtained by using two sands of rounded grains, but different diameters, mixed in equal parts.

It has been remarked by Ries and F. L. Gallup[4] that in connection with grain size there is probably one factor which is usually lost sight of, namely, the state of aggregation of the finer grains of the sand, whether they be silt or clay. If these separate, they will pack much closer and tighter than if cemented, or bunched together in the form of compound grains. If in the latter condition, the porosity of the mass and also the permeability would be larger, than if the grains themselves are porous. In the mechanical analysis of the sand the grains undergo much rubbing and these compound grains, therefore, may be broken up.

[3]U. S. Geological Survey, 19th Annual Report, II, pp. 209-215.
[4]Wisconsin Survey, Bulletin No. 15, p. 211.

Another method of making the test for permeability is by taking note of the time required for a given volume of water, 100cc, under a constant head, to pass through a known volume of sand. The more rapid the flow, the greater the permeability of the sand.

Fifth, the life or durability of a sand can be determined only by systematic experiments which would show the comparative effect of metals at different temperatures upon the sand, by making up a sufficient number of molds and pouring each one at a different heat of the metal used for the test. These tests should be arranged so as to be cumulative—in other words to wear out the same body of sand by repeated pourings of metal into it, without renewing any of the properties destroyed by the successive pouring heats. Such tests have not yet been made, but it is proposed to make them, and the results will be reported later.

Texture of Molding Sand

The texture of a molding sand depends upon the fineness of its grains. It is generally agreed that the most rational method of determining the texture is by means of the mechanical analysis of the sand.

The sample of sand to be tested, at least 8 pounds, is thoroughly mixed and screened through a No. 10 sieve. It is then reduced by means of quartering, and a 100 gram portion is placed in an 250cc bottle with approximately 120cc of water and agitated for one hour in a mechanical shaker. The bottle containing the sand and water is then removed from the shaker and shaken vigorously by hand for approximately one minute; it is permitted to stand for 45 seconds, whereupon the water is decanted and filtered. This series of operations is repeated until the water becomes clear. The residue on the filter is next dried and weighed, allowance being made for the weight of the filter paper. This material is designated as the clay.

The remaining material in the bottle is removed, dried and screened through the following sieves, and the amount retained on each sieve is determined:

Meshes per linear inch*.	Size of opening, inches.
20	.0328
28	.0232
35	.0164
48	.0116
65	.0082
100	.0058
150	.0041
200	.0029
Residue through No. 200.	

*These sieves are part of Tyler's standard screen scale for testing sieves.

The percentage of material retained on each sieve is equal numerically to the weight of the material in grams. The weight of the clay and the material screened should be added, and their sum subtracted from the weight of the original sample. The remainder, which is designated as loss, should not exceed 1 per cent under careful manipulation of the test.

The sands tested were No. 5 green core sand, used in both iron and brass foundries, furnished by the Portage Silica Co., a sand designated as "Finest Albany Sand for Brass", J. W. Paxson Co.; No. 000 Crescent Albany, J. W. Paxson Co.; tub sand used by the Bureau of Standards for one year; a sand composed of a mixture of No. 2 Albany, No. 000 Crescent Albany, and a small portion of Ottawa silica and a No. 0 Albany, furnished by the Whitehead Bros. Co.

The results of an examination of the five molding sands under consideration, are shown in Table I.

Method of Making Transverse Test

The cohesiveness or bonding power of a sand may be determined by the transverse test, as follows:

The sand bars are 12 inches long by 1 inch square in cross-section. They are molded in a snap flask on a level glass plate. The sand is packed in the flask and rammed as uniformly as possible, from one end to the other. The mold is first gently rammed with the thumb and forefinger of each hand and then firmly rammed once with a round wood bar from one end to the other. Then the flask is removed, and the sand bar is left on the plate. The weight of the bar and the plate is ascertained. The weight of the glass plate being known, the difference will give the weight of the sand bar. The amount of water used in molding the bars is the same as in the tests for permeability.

While the sand bar is still green, it is gently and uniformly shoved over the edge of the glass plate until it breaks off. The weight of the bar per unit length being known, it is a simple matter to find the greatest bending moment of the piece, and from that, the transverse strength of the specimen. The bending moment of the piece is equal to the weight of

the bar times one-half the distance of the end of the cantilever from the point of support, and the transverse strength per square inch is equal to the bending moment times one-half the depth of the bar divided by the moment of inertia of the section.

In every case the sand bars were broken as soon as possible after molding. In all the samples tested except the green core sand, the transverse strength of a dry bar is materially greater than that of a green bar. This difference is probably greater the larger the amount of clay binder the specimen contains. The results of the tests are shown in Table I.

Refractoriness

The refractoriness of a molding sand may be shown by its melting point. The method of determining the melting points follows:

Carefully mixed moist samples of the different sands were compressed without grinding into small compact cylinders and melted in an Arsem graphite-resistance vacuum furnace.[5]

The sample to be melted was placed in a porcelain crucible on a bed of fused alumina, and the crucible was placed within a long open porcelain tube to protect the samples from the vapor of carbon. The temperature was raised slowly enough to observe it within a five-degree range, and watched constantly through a glass window in the top of the furnace. The melting point was taken as the temperature at which the cylindrical sample began to settle and bulge, flowing perceptibly. Corners were rounded off considerably below this point, which, nevertheless, is the most definite and useful point to consider as the melting point.

The temperatures were measured with a Holborn-Kurlbaum optical pyrometer.[6] The pyrometer was sighted through the glass window, and arranged to swing away while observing the sample. The current through the pyrometer lamp was

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[5]American Chemical Society, 28, p. 921, 1906; Trans. Am. Electro-Chemical Society, 9, p. 153, 1906.

[6]Holborn & Kurlbaum: Sitzber, d. k. Akad. I. Wissensch. zu Berlin, June 13, 1901, p. 712; Ann. d. Phys., 10, p. 225, 1902; Waidner and Burgess, B. S. Scientific Paper, No. 11; Mendenhall, Phys. Rev., 33, p. 74, 1911.

measured with an accuracy of 0.001 amperes corresponding to about 2 degrees Cent. The furnace heating current was switched off not more than 10 to 15 seconds after the observed melting point, the temperature of the sample rising no more than 5 degrees Cent. above that point. After removing, the cylinders of sand, in all cases, were found to be well fused and only slightly changed in shape.

Permeability

The permeability of a sand may be determined by the time it takes a given volume of water to pass through a given volume of sand at a constant head of water. This test is made as follows:

The receptable for the sand is a brass cylinder, 2¾ inches (6.98cm) in diameter and 1 inch (2.54cm) high in the clear, and has a capacity of 5.94 cubic inches (97.37cc). The top of the cylinder is covered by a brass plate which projects about ½ inch beyond the cylinder to form a flange which is held to a similar flange of the cylinder by six screws. Between the two flanges a rubber gasket is inserted to make a water-tight joint. The bottom of the cylinder is covered by a screen of brass wire, eight meshes to the inch. The top plate is soldered to the bottom of a brass tube ½ inch in diameter and 40 inches (101.6cm) high; at the bottom of this tube a stop cock is inserted to control the flow of water. Forty inches above the top surface of the layer of sand is an overflow pipe for the maintenance of a constant head of water. This constant head could have been obtained by means of a Mariotte bottle without the use of the standing brass tube, but owing to the shifting of the brass mold, the exact height of the water column would have been more difficult to maintain.

The apparatus includes a two-gallon jar placed on a shelf above the cylinder. It contains a side outlet to which a rubber hose is attached. The other end of the hose is connected with the top end of the brass tube. The overflow pipe is connected by a rubber tube with the sink. Two pinch cocks are used, one on the tube from the water supply to the brass tube and the other on the tube from the overflow pipe to the sink.

When making the test 500cc of the sand is measured, shaken-down to the mark in a graduated beaker, emptied onto a mold board, and 80cc of water added carefully to the sand and thoroughly mixed with it. A piece of blotting paper of exact size is fitted over the screen in the bottom of the cylinder. Then the brass cylinder is filled with the sand and rammed with a small wooden rammer to the same degree of solidity as would be used in ramming a mold for pouring steam valves, and the sand is carefully leveled off. Next the sand is covered with another piece of blotting paper, fitting exactly over the top surface of the sand. The two flanges are then brought together and screwed up tight.

The pinch cock on the overflow tube is adjusted so that the water just trickles away, in order to avoid any injector action on the column of water. The pinch cock on the supply tube then is opened full, and the shut-off cock over the cylinder is opened. The first 20cc of water coming through is not timed, but from that point on the time which it takes 100cc of water to pass through the sand is recorded. Several succeeding runs are taken upon each specimen of sand examined. Generally, two different specimens of each sand are examined and three runs on each specimen are taken, so that when finished, each sand has had at least six tests.

As a rule, on new sands these various runs, both from the same and different samples, are quite uniform, but in an old, used tub sand there are various discrepancies, which may be accounted for by lack of homogeneity in the sand itself. In an old, used tub sand the water running through the apparatus is more or less discolored with impurities which have been absorbed by the sand in use.

In running water through new sands little or no discoloration appears in the discharge, but in old, used sands there is a coloring of the discharge due to dirt or impurities taken up in the process of molding. This coloring continues in extreme cases up to and inclusive of the fourth consecutive run of the water through the sand. If the transverse test of the sand be

considered in connection with this coloring of the water, it would seem to give a simple method of ascertaining when a sand had reached its limit of usefulness.

Durability

The durability of a molding sand is of economical importance. Sand literature seems to contain little or no reference to tests of this character. In the Ries & Rosen's[7] report on foundry sand, they compare a new molding sand known as Redford, from Richmond, Va., with some of the same sand after usage. The used or dead sand in the mechanical analysis showed a marked coarsening of the grains from 100 down to 20-mesh, a falling off in the amount retained on the 250-mesh sieve and a heavy loss in the clay content, which would indicate a decided change in the texture of the sand. It is proposed, however, in the near future to make some systematic tests in this direction, especially as correlated to transverse and melting point tests, to obtain more information on this subject.

A study of the results shown in Table I would indicate that for fine, light castings, No. 5503 is a good molding sand, on account of the small amount of clay it contains, and that No. 5506 is a good molding sand for a heavier grade of castings, particularly as its permeability test is so good, while its transverse strength apparently exceeds that of No. 5503 as it should do, for a heavier class of castings. No. 5505 is a good molding sand for the iron foundry, because its grains are fairly coarse and it has sufficient clay as a binder to bear its burden of metal, as shown both by the mechanical analysis and by its transverse strength.

No. 5846 proves quite plainly that its permeability has been impaired by the oxide impurities which use has imparted to it, and this is confirmed by the lowering of its melting point which has been produced by these oxides. The percentage retained on the 150 and 200-mesh sieves show that originally it was a good molding sand, and its transverse strength indicates that it is still capable of further usage. The chief indict-

[7]Report of Geological Survey, 1907.

ment against it, is that after three runs of water through it in the permeability tests, it still showed some signs of cloudiness, or in other words, dirty residues.

No. 5504, as was to be expected, showed a high degree of permeability, a great deficiency in clay as indicated by the mechanical analysis and a low result in transverse strength and a corresponding high degree of refractoriness.

Conclusions

It is generally agreed that a chemical analysis of a molding sand can tell us little or nothing about the cohesive property of a sand, its degree of plasticity, texture, or suitability for use, although it has some value in enabling us to determine the amount of organic matter it contains, which of course is a source of bonding power in a new sand, and it has some value in the selection of a sand for steel casting.

Although alumina and its compounds are necessary to form a permanent bonding constituent in a sand, one sand with an appreciable alumina content frequently may be quite plastic and cohesive, while others, with an equal amount of alumina, may not have these properties; the variability probably is due to the difference in the uniformity of the distribution of the clay particles. The degree of cohesiveness of a sand depends also upon the amount of moisture it contains; a moist sand coheres better than a dry one, although excess of moisture is to be avoided because it causes the grains to pack closer when rammed, and up to a certain point excess of water injures its permeability.

A rational analysis, as commonly made, determines the percentage of quartz, clay and feldspar present, and might afford some indication of the bonding power and refractoriness of the sand. A rational analysis has reference chiefly to the mineral contents of a sand, while an ultimate analysis has reference to the elements or their oxides, and it is generally conceded that a rational analysis is of more importance to the molder than an ultimate analysis. However, for practical purposes of comparison of one sand with another, a mechanical analysis is more advantageous than the other two methods.

XUM

The mechanical analysis gives us the true texture of the sand itself, together with a definite idea of its probable bonding value, which, taken in connection with transverse or tensile tests, confirm its suitability for any particular purpose.

Permeability, of course, is a property of unusual importance, and may be determined by the aspirator method or by the measured rate of percolation of water under constant head through a body of sand.

The permeability of a sand as an indication of its value should be considered in connection with its texture, and it is now generally believed that the average fineness considered in connection with the permeability test is perhaps more valuable than the fineness alone.

Sands for Different Metals

The size of the casting as well as the kind of metal used in the casting must be considered in the selection of a molding sand. Sands for steel casting should contain 97 per cent or more of silica, with a small amount of clay for bonding purposes.

Sands for iron casting should be loamy, and their texture varies with the size of the casting.

Sands for bronze should be of fine grain, good bonding power and should have a high degree of permeability—a rather difficult combination.

Sands for brass and aluminum should be fine grained and loamy, similar to those used in molding stove plate, and they should also possess a good degree of permeability.

The permeability may be expressed by the time of flow of 100cc of water through 100cc of sand in a vessel of the specified dimensions. This time may be 2 minutes plus or minus 5 seconds, in a sand of good permeability. Such a sand, other conditions being equal, would be adapted to almost all grades of bronze and ordinary brass. For German silver a greater degree of permeability would be almost necessary.

The durability or life of a sand is a matter of great economic importance. Very little of practical value has been

done on the study of this subject. The Bureau of Standards intends to conduct a series of researches on the life of various molding sands by actual molding tests, conducted with various metals and poured at different temperatures.

It has been suggested by various investigators that a good molding sand could be artificially prepared by crushing fine quartz, or obtaining fine quartz sand and adding a sufficient amount of clay and other bonding elements to give it the proper degree of cohesiveness; but the difficulties in the way of coating each grain of quartz with a film of clay of uniform thickness would seem to make the problem almost insurmountable; and yet, as natural molding sands become exhausted, its production may some day be of great economical importance. It might be possible to produce in this way several standard sands having every desirable physical property for specific purposes, which could serve as standards with which all natural molding sands now in use could be compared.

The Bureau of Standards desires the hearty co-operation and assistance of every foundryman and worker in metals who is interested in obtaining accurate information regarding the molding sands of our country, and would appreciate contributions of such sands for these examinations.

The author is indebted to H. A. Davis for making the mechanical analyses of the various sands; to C. O. Fairchild for the determination of the melting points, and to the several firms who have kindly placed samples at the disposal of the Bureau.

Discussion

MR. C. P. KARR:—We know a great deal about the molding sands of New York, New Jersey and Wisconsin, and possibly Illinois, but the other states have done very little in the line of investigation of this subject. The Bureau of Standards will appreciate contributions of sand from the Mississippi valley, from points west of the Mississippi, from the southern states and from other states than those I have mentioned. This

will help us to investigate the various sands, and the more sands you give us the more information we will furnish you later, because this is simply a preliminary report.

THE CHAIRMAN, MR. R. A. BULL:—This is a very important subject and it is a great benefit to us to have the hearty co-operation of the Bureau of Standards in this work. I think we ought to remember the cordial co-operation of the departments and do all we can to help the bureaus and thereby help ourselves. Dr. Moldenke, I should think you would have some ideas on this subject?

DR. RICHARD MOLDENKE:—Yes, I would like to discuss this subject. I was going to suggest that the Bureau of Standards look up the literature on the subject. This Association has worked two years on molding sands, but I have not seen any mention of it in this paper. Mr. Saunders has worked on the subject a great deal also, but I did not see any mention of this either. Perhaps you have missed this published matter.

MR. C. P. KARR:—Probably I did.

DR. RICHARD MOLDENKE:—I am very sorry. I have in my home many of the molding sands investigated. A considerable amount of work has been done on the subject, and if you will look up the records of the American Foundrymen's Association for the last few years, you will find the data. I think Mr. Saunders could say a few words on the subject that would help us a little.

MR. W. M. SAUNDERS:—What I have to say on bond really comes in the paper that I am to read, but the question of bond is very important in molding sand. The bond is dependent on the quality of the clay, and there are so many points to talk about during this short time, that I don't think I could undertake it, except really to say that I have co-operated somewhat with Dr. Moldenke; our laboratory has made a great many tests and we are still working on that subject. I think it would be a good plan if this Association would take up this subject of molding sands.

MR. C. P. KARR:—I would like to say, in answer to Dr. Moldenke's remarks in reference to the literature on the subject and the work that has been done by the American Foundry-

men's Association that the Bureau of Standards has had no correspondence with the American Foundrymen's Association in reference to molding sands and, therefore, did not know what work it had done. I have been a subscriber to *The Foundry* for a number of years and I did not see any particular reference to molding sands during the last two years. The latest reference I had was to some work done in England, a report of which was published in the *Journal of the Iron & Steel Institute*. Some of those articles gave reports of something done in Germany, but nothing along practical, technical lines. We want to establish some method by which all molding sands, no matter where they come from, can be compared. If any one of you has the mechanical ability to devise a means by which a little quantity of silt can be combined with clay, then you have solved the problem of a standard molding sand,

MR. H. E. FIELD:—If we can induce the Bureau of Standards to take over this work, there is no better time to do it than now. The work done by Dr. Moldenke was prodigous. I do not believe that anybody who was not intimately connected with it can realize the amount of work done, published in the reports of this Association, and filed away somewhere so that even our United States Bureau of Standards can not find it. That subject occupies 30 or 40 pages and took three or four years to compile, and it appears to me that it has been given too much thought to be relegated to obscurity. I believe that some absolute, definite action should be taken by this association, at this time, to turn this work over to the Bureau of Standards. In the old days we turned our standard samples for analyses of pig iron over to them, and they have kept them up-to-date. They have been a wonderful help to the many laboratories all over the country. If we can get the Bureau of Standards interested in this sand proposition so that they will appreciate the difficulties which the foundryman really undergoes, and realize that there are just as good sands in Ohio as ever came out of New York state, and a few things like that, I think the Association is going to profit greatly by it. I tried to help Dr. Moldenke, or rather had some of my men do it, and have a volume of 200 or 300 sheets filed away in one of my drawers, which I never look at for lack of time. I

hope this question will be referred to the Bureau of Standards and I am sure that Dr. Moldenke will be glad to help them for the good of the foundry cause. I hope that some arrangement will be made whereby the Bureau of Standards will not be forced to start at the beginning where he started, but can start where he left off and carry it to a successful conclusion.

MR. W. M. CORSE: — I might add a word of explanation as to why Mr. Karr apparently overlooked the valuable work done by the American Foundrymen's Association. As secretary of the Advisory Committee to the Bureau of Standards, of the Institute of Metals, I happen to know the inside history of it. The Institute of Metals has been co-operating with the Bureau of Standards for two years. We hold semi-annual meetings at the bureau, principally on non-ferrous metals. In the course of that discussion, Mr. Karr asked if our committee, which was composed of members of the American Institute of Mining Engineers, the American Society for Testing Materials, the American Institute of Metals, the Electro-Chemical Society and the American Chemical Society, did not think it would be a good thing to investigate molding sands. The concensus of opinion was that it was a good thing, so Mr. Karr proceeded to get some samples and went ahead with the investigation which he reported upon today. Apparently it was a great oversight that he was not informed of the vast amount of work Dr. Moldenke has done, but I am sure it was unintentional and I am also sure that this committee, of which Dr. Stratton is chairman, would welcome representatives of the American Foundrymen's Association. If Mr. Bull will appoint a committee to represent this Association and meet with us in Washington in November, you may be sure this matter will not be overlooked. I want to say that this co-operative work with the Bureau of Standards is some of the best work the Institute of Metals has done, particularly in view of the fact that the bureau has done the things that we ourselves, as corporations or individuals, did not have time to do, and I feel that the American Foundrymen's Association should be represented on that sort of a committee, and I think the fact that molding sand was omitted, unintentionally I am quite sure, can

be remedied by such representation. In fact, I cannot see any harm in it and I think it would be a very good thing.

MR. C. P. KARR:—I think, in view of the molding sand question which now is being investigated, it is the duty of the American Foundrymen's Association to be represented at these meetings. We hold them at the Bureau of Standards twice a year, and I think a permanent committee should be appointed by the American Foundrymen's Association to act with the Institute of Metals, the Mining Engineers and other technical societies, to co-operate with us, because we are simply the servants of the public. What we aim to do is to work out these technical problems for the benefit of all, and none are more interested than the members of the American Foundrymen's Association.

THE CHAIRMAN:—What is the pleasure of the convention concerning the suggestion that has been made? I was about to say, before Mr. Field arose, that Dr. Moldenke has a world of very valuable information about sands, and I know his disposition is such that he would be very glad to give it to anybody that could make proper use of it to extend the investigation. Mr. Field, did you have any definite thought, when you made your suggestion concerning co-operation?

MR. H. E. FIELD:—I move that a committee, of which Dr. Moldenke be chairman, be appointed from this Association to co-operate with the Bureau of Standards in the advancement of molding sand knowledge and I also include, as a part of that motion, that the entire expenses of this committee shall be defrayed from the funds of this Association.

The motion was seconded and adopted.

THE CHAIRMAN:—Dr. Moldenke, I think we should permit you to select your own members of the committee.

DR. MOLDENKE:—I appreciate the compliment very much and thank Mr. Field particularly for his courtesy. I will do everything possible to help the Bureau and will do it with very great pleasure.

Albany Molding Sand

By D. H. Newland, Albany, N. Y.

This paper deals more particularly with the features of molding sand as exhibited in the field. Its scope will be restricted to the description of the deposits in the Albany district, one of the better known sources of sands for general foundry use in the east and in some respects, perhaps, typical as an illustration of their occurrence.

The study of molding sands from this standpoint does not seem to have engaged much attention heretofore. There are one or two state reports of relatively recent issue, but aside from these, little information may be found in regard to the distribution of the resources, their geological association, extent of available supplies and other matters that have direct relation to the productive industry and that in the future may develop critical importance. In view of the wide interest that has been manifested of late in the investigation and appraisal of the supplies of other natural materials that have engineering or technological value, the lack of information upon this subject seems the more striking and prompts the inquiry whether any real incentive for such study has been forthcoming from those who should be mainly concerned—the foundrymen themselves. However the past record may stand, there is reason for encouragement at present in the active interest and co-operation which this Society has shown in the matter and which should be a very influential factor for the advancement of research.

General Features of the District

Albany molding sand is the product of a single district, but has a more extended distribution than the name might suggest to one unfamiliar with the conditions. The district includes a stretch of about 100 miles on the meridian and takes

in both banks of the Hudson river from near Glens Falls on the north to Kingston on the south. Albany lies near the center of the area, but by itself is not a very important factor in the industry, although good sand is found within the city limits.

The deposits occur here and there over the distance mentioned, but usually are restricted to a very narrow section within close proximity of the river. From Kingston to Albany county they do not reach back usually more than a mile or two from either bank. With the expansion of the valley near Albany through the entrance of the Mohawk, which occupies a broad valley that extends westward for over 100 miles, the sands attain a much wider development and are traceable on the west bank as far as Schenectady. North of the Mohawk the district again narrows preceptibly, but for a considerable interval it is still broader than the average of the southern section.

In its limits as thus indicated the district conforms with certain geological conditions which need to be set forth before the discussion of the sand deposits themselves is taken up.

The Hudson Valley

The present Hudson valley is an open, well-rounded excavation in shales and sandstones that belong to the so-called Hudson river formation of Ordovician age. These rocks seldom come to the surface within the lower ground, as they are mantled by unconsolidated sediments—clays, sands and gravels —which evidently were deposited ages ago, but still rather recently as geological time is reckoned. The latter beds attract the notice of visitors to the region owing to their being arranged in terraces, which rise abruptly from near the river to summits that for long distances are quite flat and preserve a uniform height. The terraces attain their greatest elevation in the north and also on the west edge of the district near Schenectady where their upper surface is about 400 feet above sea level. The general level of those in the middle and southern section is approximately 180 to 200 feet, but there are still lower ones in the south.

The sands and clays were laid down in standing water and their deposition dates back to late Pleistocene time when the Hudson, instead of flowing freely to the sea as now, was held

back or impounded so that its waters reached the higher levels marked by the terraces. The sediment, swept into this temporary lake by the Mohawk and other tributaries, was deposited layer upon layer until the accumulations reached an altitude of 400 feet or more above the old river bottom and extended from side to side of the valley depression. With the later lowering of the outlet the waters were drained off and the river began cutting down another channel through the soft beds which it now occupies.

The clays and sands retain their original stratified arrangement for the most part; the former especially show a division into horizontal layers or seams just as they were first deposited.

Formation of the Deposit

The clays occur mostly in the lower and the sands in the upper part of the series. The latter were laid down in the closing stages of the history of Lake Albany, as the flooded valley is called, and originally formed a mantle over the whole district. It is these surface sands that are of present interest.

At the present time the sand deposits are by no means

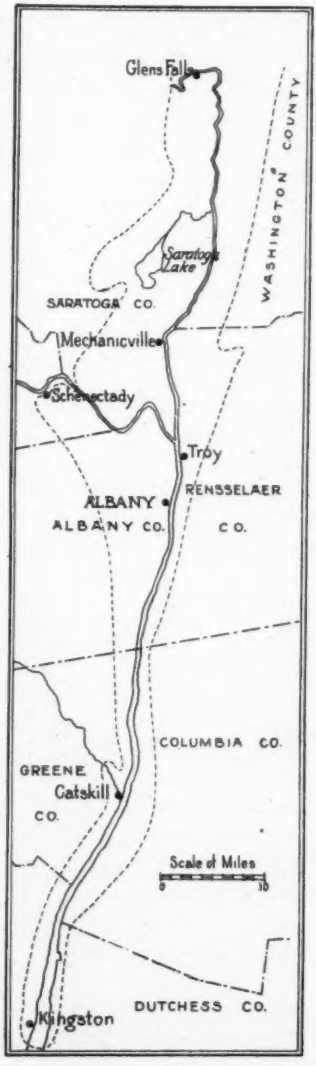

FIG. 1—MAP OF THE ALBANY MOLDING SAND DISTRICT

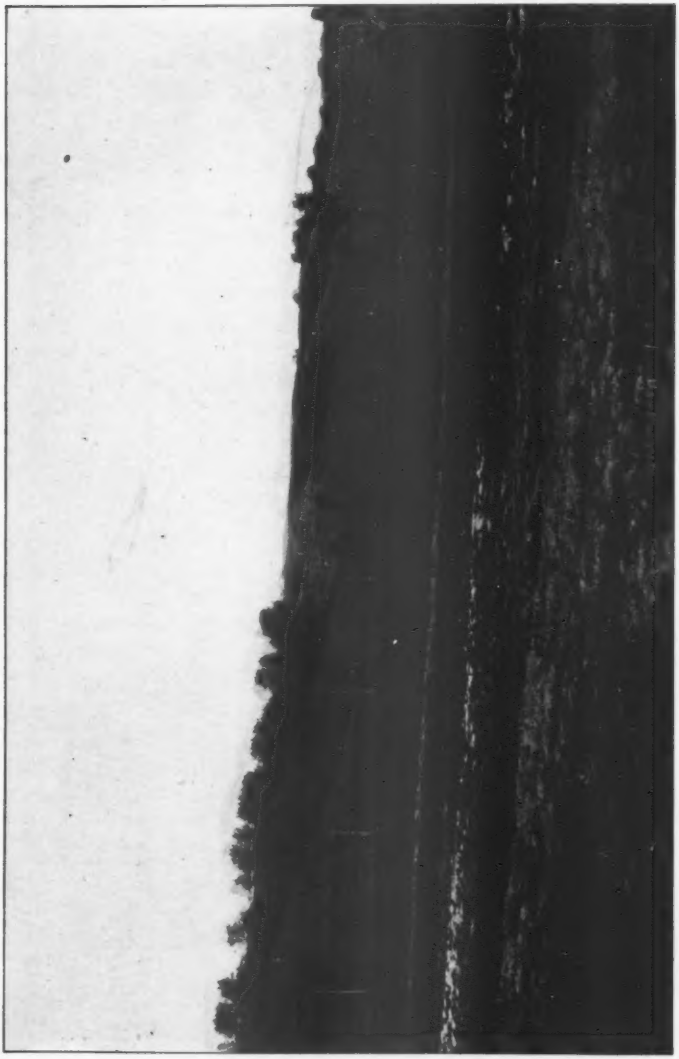

FIG. 2—TERRACED CLAYS AND SANDS IN THE HUDSON VALLEY. THE MOLDING SAND LAYER IS FOUND ON TOP OF THE BENCHES, 150 FEET OR MORE ABOVE THE RIVER

continuous over the whole district. Lying at the surface they have been subjected to erosional influences which over some areas have effected their complete removal. In general, they are not very thick, 15 or 20 feet being about the maximum, except where they have been heaped up in ridges and dunes by the work of the winds. The action of the wind has a prominent part in the present arrangement and distribution of the sands, and they are still being shifted about wherever they are not anchored by a mantle of soil and vegetation. The area covered by the old Mohawk delta contains tracts occupied by live dunes that are in course of continuous change as to form and position. Frequently, the topography bears evidences of similar wind work, although the surface may have been protected from it for a long time by the growth of vegetation.

In consequence of this working over by the winds the sand now occupies no definite position in the series, but is distributed over the surface from near sea level to several hundred feet above. Its contact with the clays below may be seen in places to be quite irregular, although originally the sands were deposited on a level platform.

Uniformity of Sand Texture

Another influence of the same agency is to be found in the evenness of texture which characterizes the sand; the first sorting by the water may have produced a fairly even grain, but no doubt this feature has been further promoted by the sifting action of the wind. The uniformity of texture does not obtain over long distances, but only within rather narrow limits, as the same layer may be seen to change gradually to a coarser or finer condition when traced along the surface. Some banks of a few acres extent may produce two or three commercial sizes. The coarsest grain seldom approaches that of fine gravel, the latter material being rarely met with among the molding sands.

The drift sand from the bare, wind-swept areas has the same textures as the sand that lies under sod, but differs from the latter markedly in appearance and in other features. It is an incoherent aggregate running readily on slopes under slight propulsion, and has no strength to speak of, when moistened.

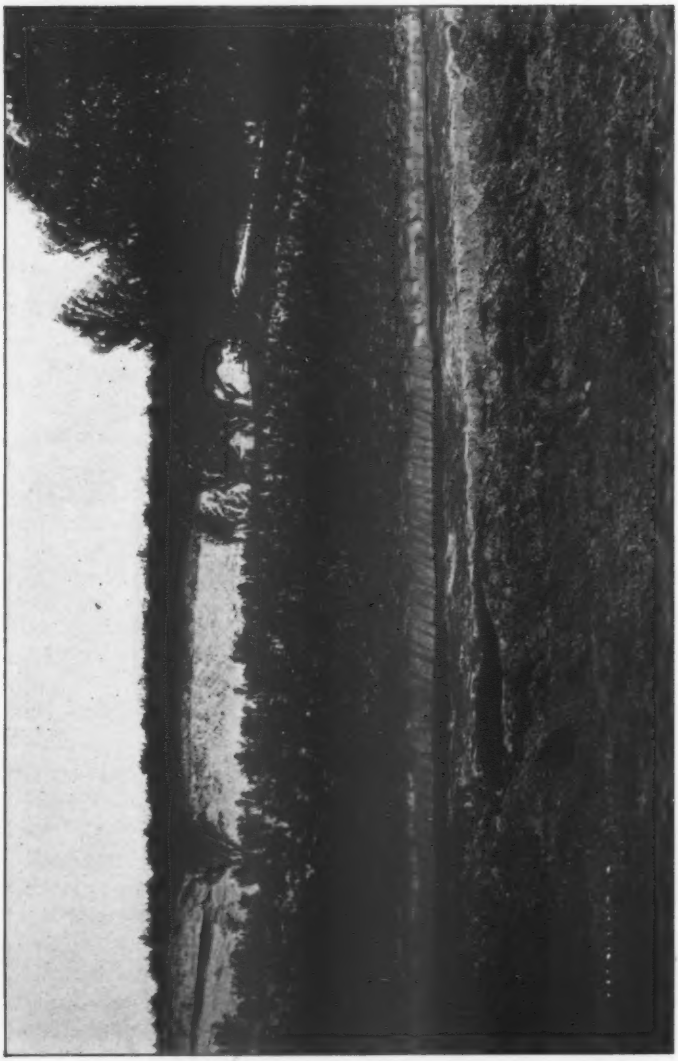

FIG. 3—MOLDING SAND LAYER IN THE BACKGROUND, WITH DUNE OF OPEN SAND ABOVE. THE LATTER HAS SIMILAR CHARACTERISTICS, EXCEPT THAT IT LACKS THE CLAY BOND

Its color is grayish from the admixture of dark grains of shale and sandstone with those of white or transparent quartz. On the other hand, the sand taken from under an old soil has a brownish yellow or ochreous color and contains enough clay usually to show good bonding power. Banks of the latter will stand vertical for a long time unless thoroughly dried out by removal of the protecting cover. This yellow, loamy sand in depth usually grades over into a sand of a looser more *open* nature which resembles more or less the drift sand.

It is rather evident from the associations that these variations reflect different stages of weathering and decomposition after the sand was deposited. Wherever the sand has been held down by soil for a long period the shaly particles have disintegrated so as to form clay and at the same time some of the iron has been released and oxidized. The change has proceeded from the surface downward under the influence of moisture, frost and probably the acids of the soil. The depth it has reached varies from place to place and is dependent upon the length of time the sand has been exposed to those influences.

The Molding Sand Layer

The molding sand represents a very small fraction of the whole accumulation of sand. Its occurrence is quite without rule, except that when present it is always the layer directly below the soil. In many places this layer may lack the necessary qualities of texture or cohesiveness to constitute a good sand, and there is no way of determining the conditions except by actual exploratory tests. The unsodded drift sand, as already stated, has little bonding power, although in texture it may resemble the commercial material.

The thickness of the molding sand layer ranges from a few inches up to 4 or 5 feet, which represents about the maximum for the thoroughly weathered layer. In the usual run of the bank the thickness probably is not much more than 18 or 20 inches. Its limits above and below are defined quite sharply, but less so in the latter direction where it changes rather quickly, that is within a few inches, into grayish, open sand. The sod cover with the soil usually amounts to 10 or 12 inches.

FIG. 4—NORMAL OCCURRENCE OF MOLDING SAND. THE SUCCESSION FROM THE TOP TO THE BOTTOM OF THE BANK IS SOIL, MOLDING SAND, OPEN SAND AND CLAY

The continuity of the layer shows no interruption, as a rule, from minor irregularities of the surface; but the sand is cut off by stream depressions and never extends far down the sides of steep banks. The product comes mainly from the upland flats, 200 feet or more above sea level.

Composition and Textures

The commercial molding sand consists almost wholly of quartz grains bonded by clay. Examination of numerous samples evidences its very simple mineral composition. Some unresolved shale or sandstone, an occasional particle of feldspar, chlorite or other silicate constitute about the only variations that may be noticed. The quartz particles when freed from the attached coating of clay are seen to be tinted a faint yellow by limonite which adheres to their surface and lends the ochreous color to the sand observed in the mass.

The ratio between granular aggregate and clay bond varies, of course, in the bank within rather wide limits. In the usual run of commercial sand of the finer sizes the latter amounts to about one-third or one-fourth by weight of the whole mass.

A feature of the sand that comes out prominently when viewed under the microscope is the angularity of the individual particles, even down to the very finest that can be seen. This is no doubt of practical significance, since it has been shown that angular particles do not pack so closely as round ones and, therefore, should have increased permeability to gases. The angularity is evidenced by wedge-shaped forms and concave bounding planes which are characteristic of quartz sands comminuted by crushing under pressure rather than by attrition or abrasion. Such sand is formed by glacial erosion. The deposits of sand and clay in the Albany district represent the finer residue of the load of rock debris which the Pleistocene ice-sheet carried along in its sweep from the north and in its later retreat left scattered over the country as moraines. The morainal accumulations within reach of the waters that drained into Lake Albany were worked over and the finer parts carried off to be deposited in the well-sorted beds which are seen today

FIG. 5—METHOD OF STRIPPING THE SOD FOR REMOVAL OF THE MOLDING SAND. THE LATTER, SHOWN IN THE ILLUSTRATION, IS ABOUT 18 INCHES THICK

Later abrasion by wind has not materially changed the character of the quartz grains.

Although several different grades or sizes of sand are obtained, it is the finer sizes which constitute the more typical material commonly associated with the name Albany sand. The grading by the shippers, as will be explained later, is not based on uniformity of practice and does not always lead to closely similar results; but in general, the sands are graded from No. 0, the finest to No. 4 which is the coarsest that is commonly shipped. Mechanical tests of No. 0 sand from different banks show that in the average from 94 to 98 per cent of the whole, inclusive of clay, will pass the 100-mesh screen, or in other words is finer than 0.147 mm (0.0058 inch). An average sample from a stock pile of this grade, to give an example, showed 96.64 per cent as passing the 100-mesh, while all but 0.71 per cent passed the 80-mesh sieve. There are few molding sands elsewhere comparable in fineness and uniformity of grain, so far as evidenced by published data.

The Methods of Extracting the Sand.

The methods employed in the production of the molding sand for the market are simple and in view of the large quantity that is shipped from the district they may appear at first as somewhat crude. The conditions, however, are such that mechanical methods can not well be adapted to the purpose. These conditions pertain particularly to the variable thickness of the layer as it is traced from place to place, ranging from a few inches to 2 or 3 feet and to the rather abrupt changes of texture which occur and which require that constant attention be given lest the grades become mixed.

The entire operation of removing the sod, and excavation of the sand is carried out with the hand shovel. The usual practice is to work the ground in sections, according to the number of grades that may be present in the land. The first work is to take off the sod, carefully cutting down to the lower limit of the soil, from a strip a few rods long and about 3 feet wide. The sod and soil after the first strip is worked are

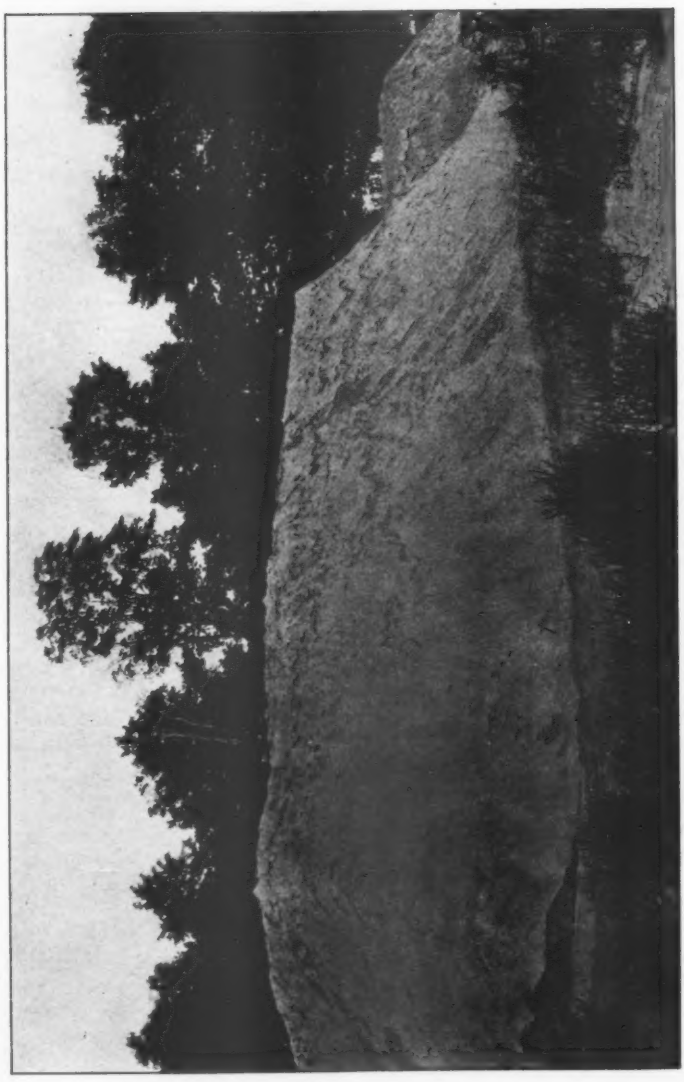

FIG. 6—MOLDING SAND IN STOCKPILE AWAITING SHIPMENT

placed on the excavated ground, which practice is followed throughout so that at the end the land may be returned to agricultural use without material decrease of fertility. The bank of molding sand which is thus exposed is shoveled into wagons, care again being necessary not to extend the cut below the layer into the open sand. The sand is thus hauled to the nearest siding for shipment, or is placed in stock pile for loading in the future.

The business for the most part is in hands of regular dealers who carry on operations in several places and are able to supply the various requirements of the market. The individual land owner seldom has enough familiarity with the grading of sand to enable him to undertake the business. The right of digging the sand on a parcel is sold under contract, the shipper paying either a lump sum or on a tonnage basis with the agreement that he shall have a certain term of years in which to complete the removal. The amount that is paid depends altogether on circumstances which vary with each particular tract, such as the grade of the sand, thickness of the layer, and distance to railroad siding, if in the interior, or to the river if that be near.

The Crop Obtainable

The crop obtainable is placed roundly at 1,000 tons for each 6 inches of thickness, a 30-inch layer thus yielding 5,000 tons to the acre.

Haulage is one of the largest items in the cost and one that can not well be reduced; it is likely rather to increase as time goes on and the more accessible lands are exhausted. About 5 miles is the maximum limit of haulage at present.

The methods of production are the same as were employed in the beginning of the industry in the district, but it is doubtful if they can be materially improved as to mechanical features. The absolute need of personal contact with and supervision of the operations is a bar to any great change in that respect.

The weakest feature of the practice, in the writer's estimation, is the lack of positive standards for the grading of the sand in the field. As conducted at present, the grading is a

matter of rule-of-thumb tests, dependent for their value upon the skill and experience of the practitioner and consequently involving an indeterminable personal factor. In such circumstances it could hardly be expected that uniformity of grading would obtain between different producers; on the other hand the way is opened for considerable variation not only as between different producers but also with regard to separate shipments from the same source.

Just how far-reaching the results of such lack of precision in grading molding sand may be is not within the writer's knowledge, and is a matter which the foundrymen themselves can best answer. The methods alluded to are in general use throughout the industry, not peculiar to the Albany district by itself, so that the same conditions probably hold with respect to sands of different origins.

Any plan for improvement of the practice would seem to have its basis in the introduction of physical tests in line with those employed in laboratory work, but not necessarily so refined or comprehensive as the latter. The Albany sands show a degree of constancy in many features that makes for simplicity in the testing operations. They are all quartz sands of high purity, at least the weathered surface portion that is the source of practically the whole output, and the constituent grains are of similar physical development, differing only in size. The bond is also of similar nature throughout. Consequently, the features upon which the varied properties of the sands in use depend are first the relative grain sizes and second the clay percentages. A method for comparison of these features that is readily applicable in the field should not prove difficult to find, in fact may be said to be already at hand. The examination for size is merely a matter of screening with a set of standard sieves, as explained in another paper by C. P. Karr. The estimation of the percentage of clay bond may be performed by rubbing a moistened sample in the fingers to secure disintegration and then shaking it well in a graduated glass cylinder with sufficient water; the contents are then allowed to settle, when the

clay will form a distinct layer above the sand. The volumes of each may then be read directly from the scale. This method is not very precise, but sufficiently so probably to serve the purpose of field classification.

Production and Supply

The present output is obtained from numerous localities that altogether are scattered pretty well over the whole district. By far the largest share, however, comes from the central section, that is within a stretch of 20 miles or so north and south of a line drawn between Schenectady and Albany. Among the more important localities for the shipment of the sands are Elnora, Round Lake and Mechanicville, Saratoga county; Albany, Wemple, Selkirk and Delmar, Albany county; South Schenectady and Carmen, Schenectady county; Rensselaer and Van Hosen, Rensselaer county; Coxsackie, Greene county; Rhinecliff and New Hamburgh, Dutchess county; and Kingston, Ulster county.

The annual production ranges from 300,000 to 500,000 tons a year. The following statistics represent the aggregate production of molding sand in New York state for the years 1908-1914 as collected by the State Geologist's office. They may be regarded as practically equivalent to the output of the Albany district, for the industry outside is very small:

Output of Molding Sand

Year.	Tons.
1908	312,819
1909	468,609
1910	471,351
1911	476,014
1912	469,138
1913	504,348
1914	310,727

A production of 500,000 tons a year means the exhaustion annually of about 125 acres of a 2-foot layer, based on an estimated yield of 1,000 tons for each 6 inches of sand on an acre which is said to be about the rate of yield. On this basis a square mile of territory is worked over every 5 years.

There is no doubt that the supply has been appreciably diminished by past operations which have been conducted on an extensive scale probably for the last 50 years or more. This is shown by the fact that the sand is now hauled from more distant points than formerly. Yet there is a large amount of unworked territory, sufficient probably to meet the demand for a long time to come, but at somewhat increased costs of production. The supply of the finest grade is likely to give out first, since it is not so plentiful as the others.

The production of artificial molding sands to compete with the finer grades of Albany sand does not appear feasible, so long as the latter can be obtained at moderate cost. To grind such a tough material as quartz to a similar degree of fineness is expensive, and there are physical difficulties which may prove insurmountable, so far as practical operations are concerned. One of these is the close attachment or adhesion between the clay and the quartz, which no doubt is promoted by the slightly corroded or roughened surfaces of the grains and their film of iron oxide. Furthermore, it would probably be very difficult to obtain an even distribution of the bond comparable to that in the natural sand of which every particle is separately coated by clay.

Discussion

MR. R. F. HARRINGTON:—If there is to be a further discussion of this paper, I would like to ask the speaker if he really believes any means will be devised whereby an analysis can be made in the field? From a trip I took in New Jersey, looking over the sand banks, it seemed almost impossible that a plan could be devised whereby a representative sample of the sand could be obtained from the bank. I would like to ask the speaker if, from his experience, he believes that an analysis could be made on the field which would be representative of the material shipped to the customer?

MR. D. H. NEWLAND: — That is a matter to which I have given little attention. I hoped that it might be brought out by Mr. Karr. My attention has been chiefly devoted to the distribution of sands and the method of their occurrence. I do not know how far physical tests may be practical in the field, but the present situation seems very unsatisfactory; every superintendent of a sand bank has his own standards of classifying sands, but all he does is to rub the sand between his thumb and forefinger to feel the texture and press it in his hand to see if it is strong or not; then he grades the product as No. 0, No. 1, or whatever it may be, without any really scientific test as to the fineness of the sand or the texture. Of course, every man has his own personal equation. Some men's sense of touch and feeling is finer than others and necessarily there is a great variation, as I have noticed, in the grades of sand as shipped by different concerns. It seems to me that this matter would be worthy of the attention of the Association or of experts.

THE CHAIRMAN, MR. R. A. BULL: — Mr. Newland, don't you think it might be entirely practical for each sand bank owner to have a few screens, and by the use of them, judge as to the fineness of different deposits he might have?

MR. D. H. NEWLAND: — I think that might yield an approximate result and would be an improvement over the present method.

THE CHAIRMAN: — And some such means as Mr. Karr has referred to in his paper?

MR. D. H. NEWLAND: — Yes, if they can be simplified to meet the conditions which naturally are different than those of laboratory testing.

THE CHAIRMAN: — Concerning the use of transverse tests —an overhanging slab might be employed to determine cohesion. I would think that might be practical. I would be glad to have some suggestions on that line.

MR. R. F. HARRINGTON:—The speaker stated that he finds the same grade of sand varying when it comes from different producers. In our experience, that is that of the Hunt-Spiller Mfg. Co., we find the same producer shipping

supposedly the same grade or quality of sand, yet we find, on examination, considerable difference in quality and refractoriness. We not only need standardization in the grading among different producers, but the producer must be brought along to that point where his handling of sand makes the grade of sand shipped to the consumer, more uniform from cargo to cargo.

THE CHAIRMAN: — The sand is taken from different places probably.

MR. R. F. HARRINGTON: — Yes.

Reclaiming Molding Sand

By W. M. Saunders and H. B. Hanley, Providence, R. I.

Foundrymen have long recognized the need of some way of reclaiming, or bringing back to its former condition, used molding sand. In some localities this need has not been so apparent as in others where the first cost of the sand and the cost of removing waste have been exceedingly high.

Not only the reclaiming of old sand appeared important, but keeping the sand in actual use in good or improved condition became an attractive proposition.

Many investigations and experiments have been made with the view of improving and reclaiming molding sand. Some of the results of these investigations were considered of enough value to protect the process by patents. Patents have been issued for machines to be used in treating and tempering molding sand, also for the addition to the molding sand of various chemicals tending to improve the molding qualities of the sand. In some of these patents it was claimed that certain chemicals would restore that property which the sand lost when heated in contact with molten metal.

What takes place when molding sand is heated is not definitely known, but one result is of importance to foundrymen, that is, the loss of bonding power. Molding sand heated a little above the temperature of boiling water loses very little bonding power. As the temperature to which the sand is exposed is increased a greater loss takes place until at the temperature of red hot metal the bond is destroyed and the sand no longer possesses the property of molding sand.

The loss of bonding power is well illustrated by the following experiment: Molding sand having a bond expressed by the number 480 was heated for the same length of time at

different temperatures. The result of the heating was to reduce the bonding power as shown in the accompanying table.

Loss of Bonding Power of Sand as a Result of Heating

Heated at Degrees Cent.	Bonding Power, Number.
100	480
300	380
500	260
700	260
900	160
1000	120

Heating for a longer period at 1,000 degrees Cent. caused the complete destruction of the bond.

Loss of Bond in Contact With Hot Metal

It is evident that all molding sand in contact with very hot metal loses bond, and the longer the time required for cooling the casting the greater the penetration of heat into the sand mold, and consequent larger loss of bond. For this reason it is desirable to remove the castings from the sand as soon as all danger of too sudden cooling has passed.

The bonding property of molding sand is due to the amount and quality of the clay contained therein. In determining the bond of molding sand advantage is taken of the well-known fact that clay has the property of adsorbing various dyes, the amount adsorbed depending upon the quality or plasticity of the clay. Hence, in molding sand the greater the plasticity and bonding power of the clay present the larger the amount of dye adsorbed.

Probably the earliest investigator to recognize the value of dye adsorption applied to molding sand was Dr. Moldenke. The result of his extensive work has been published in the *Transactions* of the American Foundrymen's Association, Vol. 21, 1913.

There are three important tests to be used in studying the value of molding sands: Rational analysis, mechanical analysis and bond test, as indicated by the dye adsorbed.

The rational analysis consists of treating the molding sand in a manner to show the amount of quartz, feldspar and clay substance contained. The mechanical analysis consists in sep-

arating the molding sand into various sizes, held on sieves of increasing fineness, and is usually expressed in percentage held on the different mesh sieves. The bond test consists of treating the properly prepared molding sand with a dye dissolved in water, and the result expressed as milligrams of dye adsorbed by 100 grams of the sand. The mechanical analysis and bond test as employed by us will be described later in this paper. A method for the rational analysis has been described by Dr. Moldenke.

Restoring Bond to Molding Sand

For the purpose of restoring bond to molding sand by the means of clay, we have been carrying on experiments for about three years. The experiments were made in a large foundry employing molding machines making pipe fittings. The molding sand from the state of New York was known as North river sand, and had the following mechanical analysis and bond test:

Mesh.	Percentage.
20	0.09
40	1.69
60	11.47
80	13.39
100	7.08
150	22.84
200	9.14
200+	17.32
Clay sub.	16.92
Bond test 500.	

The foundry was constructed after the two-story style, the castings being shaken-out onto a grating through which the molding sand passed to the floor below to be mixed with new sand, tempered and returned by means of conveyors to the molding machines. The castings, with sprues and adhering sand, were picked up from the grating and dropped through a chute to the floor below. Considerable adhering sand was rubbed off the castings in passing through the chutes, and accumulated on the floor at the bottom of the pile of castings. This burned and waste sand having a bond of less than 100 was reclaimed and added as new sand to the molding sand being used.

The method of reclaiming this burned and waste sand was as follows: The sand was first passed through a sieve to

remove pieces of iron. It was next mixed with New Jersey fire clay having a bond of about 2,500, in the proportion of three parts of burned sand to one part of clay. This 25 per cent clay mixture was then passed through a grinder, not for the purpose of making it finer, but to thoroughly mix the clay and sand by rubbing the particles together, and thus bring them in contact. By means of this it was believed the clay would cover and adhere to each grain of sand, replacing the bond destroyed in the original molding sand. A new molding sand was thus made having a bond of about 600 to be used in place of natural molding sand. No other molding sand but this reclaimed sand was used by a number of molding machines for several months.

Results of Mechanical Analyses

Mechanical analyses made upon samples taken from the sand used on a molding machine making 2-inch elbows at the beginning of the experiment and at the end of one month, three months and six months after, gave the following texture and bond:

Mesh.	Beginning, per cent.	One month, per cent.	Three months, per cent	Six months, per cent.
20	1.80	2.08	2.72	2.22
40	5.78	4.60	7.20	6.50
60	11.40	10.80	11.32	11.37
80	11.44	12.32	11.50	10.64
100	6.04	5.88	6.62	5.90
150	21.33	23.16	20.88	21.20
200	9.77	9.06	8.44	9.23
200+	19.16	18.52	17.40	17.40
Clay substance	13.28	13.58	13.92	15.54
Bond test	304	336	344	312

It was found that the quality of the clay used for bonding should be suitable for mixing well with the waste sand, have high plasticity as indicated by the bond test, and be as highly refractory as possible.

Later experiments showed the ground New Jersey fire clay possessed properties which made it possible to be mixed as a bonding clay with the waste sand by means of shovel and riddle, the grinder being unnecessary.

No attempt was made to clean the burned or waste sand by removing the finer portions, as the coarser bank sand carried into the molding sand by cores helped to keep in balance the fine clay material.

Mechanical Analysis

To make the mechanical analysis, 25 grams of molding sand are placed into a 500cc. wide-mouth glass-stoppered bottle, and 300cc. of water are added. A deflocculating reagent is next introduced into the bottle. For the purpose sodium hydroxide, sodium carbonate and ammonium hydroxide are very well adapted.

Molding sands from various parts of the United States are affected differently by the kind of defloccculating reagent employed. Sands from Ohio and Kentucky are deflocculated best with sodium hydroxide, New Jersey with sodium carbonate and New York with ammonium hydroxide. A few preliminary tests on a sand from an untried district will soon indicate the reagent best suited for removing the clay, and separating the sand into its individual grains.

The deflocculator selected should be added in very small amounts, namely, 50 milligrams in case of sodium hydroxide; 200 milligrams of sodium carbonate; or 2.5cc. of ammonium hydroxide, sp. gr., 0.90.

The glass stopper is then put in its place in the bottle, sealed with paraffin wax, and the whole rotated on a machine making about 60 revolutions per minute. The bottle being inverted at every revolution a complete agitation is imparted to the sand. After rotating for one hour the contents of the bottle are emptied and washed onto the first and coarser of a series of standard sieves in the following order: 20, 40, 60, 80, 100, 150 and 200 meshes per inch. A jar holding about one gallon directly below the lower or 200-mesh sieve receives the finer portion along with the clay substance. The washing of the sand through each sieve is carried on by using a stream of water possessing sufficient force and volume to carry the smaller particles through the larger meshes until they reach the proper sieve or pass into the jar below. Without removing the first or 20-mesh sieve from the nest it is washed with the stream

of water until all the material capable has passed to the next sieve. It is then placed to one side and the 40-mesh is treated in the same manner, and so on, until the contents of all the sieves have been thoroughly washed. Each sieve is then wet with alcohol, dried at 100 degrees Cent. and the sand transferred to a watch glass and weighed. The fine material in the jar is allowed to remain undisturbed for five minutes, then the clay substance decanted off. Water is added to the jar, the suspended particles decanted off after remaining undisturbed for five minutes, and this repeated until the added water remains clear. The material remaining in the jar is designated as 200 plus mesh. This is collected on a filter paper, washed with alcohol, dried and weighed. The clay substance is obtained by subtracting the sum of the percentage of all the other sizes from 100 per cent.

Bond Test

In making the bond test, 25 grams of the molding sand are placed into a 500cc. wide-mouth bottle fitted with a glass stopper, and 250cc. of distilled water and 5cc. of 10 per cent ammonium hydroxide are added. The bottle is then stoppered, sealed with paraffin wax, and placed in the rotating machine for one hour. At the end of this period 140cc. of distilled water are added to the bottle and also sufficient acetic acid to neutralize the alkali and leave a slight excess of acid to flocculate the colloidal matter, usually 5cc. of 10 per cent acetic acid being required. Crystal violet dye is then added in sufficient weight to allow for the adsorption by the colloidal matter and leave a slight excess. The bottle is then sealed and placed in the rotating machine for two hours. If all the dye is taken up by the colloidal matter then a small weight of dye should be added, and the rotating continued.

In order to determine the amount of dye adsorbed by the sand it becomes necessary to find the quantity unadsorbed or held in solution. This can be done in comparison tubes by comparing the depth of color of the water solution with a standard color solution made from a known weight of dye. Unfortunately, considerable suspended matter remains in the

supernatant liquor containing the unadsorbed dye, and prevents accurate comparison. The dye can be completely taken out of solution by means of mordanted cotton yarn.

After removing the bottle from the rotating machine it is allowed to stand for a few hours until the coarser particles have settled to the bottom; 100cc. of the supernatant liquor is transferred to a beaker, 25cc. of water and 2cc. of 10 per cent acetic acid added. The beaker is placed in a water bath at room temperature, and a five-gram skein of mordanted cotton yarn introduced into the solution. The skein is worked for 20 minutes, then for another 20 minutes the temperature of the solution is slowly raised to 60 degrees Cent. while working the yarn. The dyeing of the skein is completed in 20 minutes more, working with the temperature of the solution at 60 degrees Cent. All the dye should be removed from the solution, the suspended matter from the molding sand remaining behind. The skein is then washed and dried at 70 to 80 degrees Cent. Comparison of the color on the skein is made with standard skeins, a set of which is kept preserved in the dark. The standard skeins are prepared by depositing upon each, in the manner described, 6, 8, 10, 12, 14 and 16 milligrams of crystal violet.

Discussion

THE CHAIRMAN, MR. R. A. BULL: — I was just wondering whether you could submit any approximate figures as to the cost per ton of washing the sand?

MR. W. M. SAUNDERS: — We have not had any experience with washing sand. I think that Mr. Lane had a paper a while ago on washing sands and also cleaning them by air pressure, but I think I made the statement that we did not clean the sand.

MR. A. B. ROOT, JR.: — The Hunt-Spiller Mfg. Co. has had some little experience with the work Mr. Saunders has

outlined. In the past eight years the requirements of the particular profession that we have been engaged in have so increased as to demand a constantly better finish to the castings which we are producing. To maintain this, we have to keep what we consider a very high grade heap sand, and in keeping track of our sand we have worked with Mr. Saunders, and I am in hopes that he will perhaps amplify his report by a description of the work that has been done in our shop and other shops, in the application of the principles which he has given in his paper. We feel there is a great deal to be learned in the control of sand, as the opinion of one foreman differs widely from that of another, as to the quality of sand and as to the amount of bond which he thinks it contains and as to what he thinks the bond is. Mr. Saunders has described what that bond is, and I think that it would be very interesting to have him perhaps go into that a little further.

Mr. W. M. Saunders: — It would take some time to go into the subject of what bond is, except that it is a property of clay. Of course, we recognize in clay a certain condition; we call it a colloidal condition. Now, collodial matter may be organic or inorganic. The organic bond is destroyed readily by the heat. The inorganic bond is not destroyed so easily. We can divide the inorganic bond into two classes—the hydrated oxides of silica and alumina and iron, and also the hydrated silicate of alumina. These all possess this particular quality of adsorbing dye, which we say is due to colloids; so really the bond of a clay depends upon its colloidal condition. These colloids may be just developing. It is done in nature by weathering; or they may have been already produced, and so in selecting a clay for bond, great stress should be laid upon the fact, or the tests, rather, that we have outlined, that is the bond test, or the adsorption of dye; just what the clay does I am not prepared to say. We know it surrounds the grains. We know that by heating we destroy this attraction and the value of the sand or its particular quality is lost. Now it was for the purpose of restoring the bond—I will say this is not a new idea—that we tried these experiments and you see the whole process depends upon the quality of the clay used.

MR. A. B. ROOT, JR.: — My idea was perhaps to have him say this, that after the heap has been used for a certain length of time, a certain amount of that bond is burned out. The question how to definitely determine how much bond remains in that heap, then arises; to know how much new sand should be added, or if new sand is not necessary, how much clay substance should be added, and in what form, to best mix with this heap sand, to raise the bond to the proper point; and that, to my mind, is the principal thing. We see at the exhibition a machine which is adapted to mix clay, or new sand, with old sand, which is perhaps an indication that something of that nature is coming. We have heard it said that sooner or later the natural molding sands will have been exhausted and that some means must be provided for making molding sand. This is perhaps a forerunner of that condition, in that it deals with the amount of clay substance which must be added to the sand to produce the bond which is required for any particular work.

MR. W. M. SAUNDERS: — As for the control of the heap, that is best done by the bond test, as we call it. If we find the dye figure, dye adsorption, is going down, we put in more clay. It can be readily figured out. If the clay adsorbs 2,500, it would be 2½ grams of dye to 100 grams of clay. We know readily how much clay to put into the heap to bring it back to its normal strength. Control tests have been made in some of our experiments, extending over a period longer than a year, all based upon this test. We have found that when the heap ran below a certain number that the castings began to show the effect, that is, it was bad sand. By increasing the clay, or adding new sand to bring this bond up to where it should be, the castings came good, so that the control of the heap really depends upon this bond test.

MR. J. J. WILSON: — I would like to ask the speaker what clay he has found to be the best? You spoke of the Jersey fire clay. Do you consider that the best for that purpose?

MR. W. M. SAUNDERS: — We have adopted Jersey fire clay because it is nearer home. There are some clays through the west that are better for the purpose, but, of course, the freight cost is too high for the New England foundrymen. If

we can get just as good results from the Jersey clay, of course, it pays to use it.

MR. J. J. WILSON: — What clays could you mention in the west?

MR. W. M. SAUNDERS: — I cannot give you the names just now. The Bureau of Standards has helped us out a great deal on information as to where we could get clays. The Tennessee ball clay is one that is quite plastic, in fact, it is a good deal too plastic to grind.

MR. H. E. FIELD: — Have you ever established the point where it pays to do that? Have you ever figured out at what price of molding sand or clay it pays to use that method over using new sand?

MR. W. M. SAUNDERS: — If you can buy molding sand at $1.50 per ton, I don't think it would pay to reclaim the used sand.

MR. W. H. ALKOHN: — I understand from Mr. Saunders' paper, and several papers I have read on the subject of reclaiming molding sand, that the idea seems to be really to introduce a clay. The general theory is that the molding sand, as we understand it, will eventually give out. I take it from most of the papers, that manufacturers of sand grinding machinery claim that the clay must be ground into the grains of sand. As a molder, I think that in grinding clay, if you have a certain amount of clay ground into every grain of sand, your whole heap will become so dense and so compact by the clay that it will not make a good mold. I believe there must be some open sand there in order to mold properly, if nothing else. Now, why dry clay was introduced, I don't know. I remember, some fifteen or twenty years, ago, although I am not an old man at that, hearing of clay wash being introduced. Whether it was successful or not, I don't know, as at that time I was too young to appreciate what was being done. The firm where I am now working introduced dry clay. We do not grind it in with any grinding machinery, but shovel it through and riddle it. Certainly our proposition is different from that of a good many shops. Rather than make a facing and bank it up against the side of a pattern, filling the flask with com-

mon heap sand, we make a heap of facing sand and fill the whole flask with it. That sounds rather expensive to a good many, but in the end it has proved about the most satisfactory. There is one point I would like to understand thoroughly, whether the idea is to grind the clay into every particle of such grains of sand as have no clay bond, or whether mixing through the heap will do.

MR. W. M. SAUNDERS: — The ideal molding sand is one that has just enough clay around each grain to stick the grains together. If we introduce dry clay into dry sand, mix them and put them through a riddle, we bring them into contact, but the grains are not coated. When that sand is wet and allowed to temper, grains of clay break up and eventually we have the grains of sand covered with clay. The ideal method, of course, would be to rub the clay and dried sand together, thus coating the grains of sand.

MR. W. H. ALKOHN: — I understand that in a way, but the grinding machines of today grind the clay into the sand and crush up the grains of sand, especially for heavy work, to a fineness that we do not want in molding practice. It is not open enough. This to me is one objection to grinding clay directly into the sand.

THE CHAIRMAN: — You are speaking of the mill grinder, of course?

MR. W. H. ALKOHN: — Yes, sir.

MR. W. M. SAUNDERS: — I will have to differ with the gentleman a little, because we have used, instead of a mill grinder for this purpose, a method of rubbing together, and it does not grind, it simply rubs the clay and grains of sand together. The sieve test or mechanical analysis shows that the grain does not change at all.

THE CHAIRMAN: — You do not pulverize the particles?

MR. W. M. SAUNDERS: — We do not carry it far enough for that.

MR. E. M. AYERS: — Ohio, where I come from, is a pioneer in making combinations such as sharp sands with clay. Probably it would not be far from a correct statement to say that 25 per cent of the sand in Ohio, outside of stove

plate, is a modification of sand and clay as referred to by the speaker. Knowing the kind of sand you want to make, you select your grain, which is sharp sand. The main thing, then, however, is to find the clay. As the speaker has said, there is a difference in clays in making the bond. With us, that is the prime feature and the thing we always aim to control absolutely is the kind of binder. Clays that look similar to a novice may not be fit for use as the binder of a molding sand. An effort is being made to arrive at a sieve test for sand and that is something we have tried to do for thirty years and have not found the answer I have read all the papers that I have been able to obtain and heard all the talks I could, without success. We, as producers, are more anxious to find that than the user. The difference we find is in the binder. The binder of a fine molding sand, if you separate it, is silt. The binder of a loam sand or a heavy sand, is clay. The grains do not vary a great deal. As the Albany sand gentleman pointed out, the sand shipper tests his sand by rubbing it between the first finger and thumb, and that is the test throughout Ohio. If some practical test could be devised at the shipping point, I think there is not a sand man in the business who would not be very glad to have that worked out. The question of producing sand to grade, as required by the difference in the character of the work produced by foundrymen, has brought about the production of milled sands. Over half of the sands that come out of Ohio are milled. I presume 25 per cent of them are combination sands, excepting stove plate sands and in Ohio some of those also are blended. However, the stove plate sands today are generally used in their natural condition. Take Pittsburgh loam, for example, and wash a little of the bond out of it, and at once it will be seen that the character of that material is very different from ordinary clay and very different from a brick clay. In our country, where there is a very large production of brick clay, a clay that will make a brick won't make a sand, because there is no sandy clay in it. As I said before, take the silt in a stove plate sand and the loam in a heavy clay sand, and you will see the difference in the two materials. If you will have a test that the sand producer could use as a guide, it will also solve the troubles of the foundryman.

MR. S. STONEHAM: — Do I understand the speaker to say that in reclaiming sand he is going to take it from the gangways, riddle the iron out of it, or the steel, or whatever it might be, put it back into the heap, and after that is there, he really wants a little clay to act as a bond so that the molder can use the sand physically? That being so, I would like to ask the speaker what would happen to the silica portions of the sand, being burnt so often.

MR. W. M. SAUNDERS: — I do not quite understand what you mean by silica portions. You consider the molding sand made up of various minerals. These minerals may exist as silica, as you say, and also they may be silicates. There is no trouble in heating these. They do not change their form very much. If they are heated very hot, they simply stick together and increase the grain of the sand. The heating destroys the bond or the bonding power, and that is restored by clay. That has been our experience for some time. We have carried on these experiments, and I have described one carried on for six months and you notice there is no great change in the size of the grains of the heap. No new sand went into these heaps for over six months.

Functions of Sand Binders

By H. M. Lane, Detroit

In foundry practice a sand binder is that agent which holds the grains of sand in the body of a mold or core in place when the metal is introduced into the mold. The binder must be of sufficient strength to hold the sand rigidly until the surface of the metal has solidified to form a protective skin. At the same time the binder must be of such a nature that it will release the sand grains after the casting is set, so that the sand can be cleaned off with the greatest possible ease.

Dry sand molding, skin dry work, green sand molding, dry sand cores, and green sand cores, merge into one another so closely that it is impossible to separate these classes by any distinct lines or division, hence in this paper the subject of binders will be considered in relation to sand regardless of whether the sand forms the body of the core or mold.

There is one point in regard to binders that should be made plain at the beginning, and that is that binders exert two different influences at different points of the molding or coremaking operation. In the case of dry sand molds and cores, it is necessary to have something to hold the body of the sand in shape previous to and during the drying process. The agent used for this purpose is commonly known as a green binder. In the case of green sand molds and cores the green binder only is required.

Classification of Binders

There are a good many ways in which binders can be classified, but probably as good a general classification as we can find is to divide them into water soluble binders, paste binders, colloids and allied bodies, and gums, pitches and oils. The first two classes are all subject to moisture, and cores made from them are likely to soften if exposed to moisture. The colloid bodies may or may not be subject to injury from

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moisture, while the gums and pitches are as a rule water-resisting or water-proof.

Under the heading of water soluble binders we have molasses, sour beer, distillery refuse, paper mill waste products such as glutrin, corn syrup waste products such as hydrol, glue and silicate of soda.

Under the paste class we have three general types known as flour, starch and dextrine. The flour includes wheat and rye flour, fine ground white corn used as an adulterant for wheat flour and pea meal. Under the starch class we have corn starch, wheat starch and potato starch. Dextrine is made from starch and gives a stronger paste than the other starches used.

Under the colloid class we have clay, magnesia, milk of lime, alumina compounds and iron compounds or combinations of these. The binding power of horse manure or cow manure is due to the colloidal nature of some of its ingredients, and also to the reaction which it has with the clay which serves to increase or support the colloidal condition of the clay.

Under the gum class we have resin, pitch obtained from the distillation of coal in making illuminating gas, or tar from gas producers, pitch from the destructive distillation of wood, and various kinds of asphaltum or pitches from petroleum products.

Under the oil class we have at the head of the list the drying oils which are headed by linseed oil, and chinawood oil. The iodine number of an oil as taken in the paint trade forms a very good index as to their binding properties. This class includes whale oil, and various fish oils such as manhadden oil, soyabean oil, cotton seed oil, sun flower seed oil and a large variety of oils of vegetable origin.

Next we have the filling oils which are used largely as adulterants with the drying oils. There are four general sources for this class of oil. First, the class known as neutral oils which come from petroleum. Second, the tar oils which come from the ordinary rectification of gas house tar. Third, a small class of oils which are made through a destructive distillation of certain coal or shale products, which are produced

in small quantities for the paint trade. Fourth, resin oil which is made from the destructive distillation of resin. There are also oils from the destructive distillation of wood.

The action of the various binders mentioned have considerable to do with their sphere of usefulness. It may be wise first, however, to consider something of the different conditions to be met by sand binders.

Binder Requirements

When casting aluminum we are face to face with a very light metal which sets quickly after pouring, and which has hot-short tendencies. The fact that the metal is light, or of low specific gravity, results in the molds not being subjected to serious pressure due to the head of the metal during the pouring. Its quick setting and low pouring temperature protects the sand from great heat, and at the same time gives little available heat to burn out or reduce a binder. Its hot-short tendencies make it necessary to have a core which will crush readily. This means that for this type of work we must either have a soft, pliable molding or coremaking material such as a soft, green sand mixture, or we must have a binder which softens immediately upon exposure to heat so that it can give way before the shrinking metal. The latter conditions are met by the use of resin, and to some extent by pitch.

When we encounter a high phosphor bronze we find a metal with great searching power, that is a metal that is so fluid when molten that it has a tendency to flow in between the sand grains themselves. This character of metal calls for a core with a very tight surface, which is not very readily penetrated with the metal. This is accomplished by the selection of a grade of sand having fine grains of a comparatively uniform size with possibly the addition of some surface finish to the core or mold.

In ordinary gray iron castings we have a metal that sets much slower, and is so heavy as to have a serious lifting effect which tends to strain or change the shape of the mold, or to displace cores. Cores for this metal necessitate a much stronger material than would be required for aluminum, but at the same

time we have available many more heat units per cubic inch of molten metal, and this tends to disintegrate or break down the binding material so as to soften the core.

In steel we find the same conditions existing as in gray iron, with the exception that we must be careful in the selection of molding sand, core sand, etc., to avoid all fusible ingredients.

Action of Binders

Referring to the binders, in the water soluble class we find that molasses binds by boiling up, and then hardens as plates of taffy or partially charged sugar. It is this boiling of the molasses just before the final set that has a tendency to deform molasses cores.

Thus far certain brands of cane sugar molasses have been found best for coremaking. Some years ago the writer carried on an extensive series of tests to ascertain the relative advantages of different forms of molasses and the effect of fermentation on the binding power of this material. The results of these tests proved conclusively that there is a wide difference in the binding power and that fermentation in any given grade of molasses would destroy over half of the binding power.

In this series of tests some interesting results were obtained from beat sugars or beat syrups. The cores made with these materials as a binder, when first baked, were of excellent strength, but they were unsatisfactory in that they would draw moisture from the atmosphere and fall to pieces on the slightest pressure. This is found to be due to the presence of certain salts in the molasses, particularly potash and soda.

Sour beer owes its binding power largely to the presence of dextrine and similar ingredients, and this also is true of distillery refuse. The ingredients present, which have not been converted into sugar and then changed to alcohol, act as binders.

Glutrin binds in a very different manner from molasses. With absolutely sharp sand it has a tendency to follow the water to the surface giving a hard skin next to the metal and a core with a soft interior. The introduction of clay or any other colloid will tend to hold the glutrin in the body of the

core which greatly increases the strength and gives a uniform structure throughout. Glutrin, like oil, draws down to the contact points of the sand, thus giving a far greater efficiency per pound of material than is obtained with many other classes of binders.

Glue, like glutrin, draws to the contact points, and gives good results, but it emits disagreeable odors during pouring and is subject to serious ferementation difficulties.

Hydrol is a residual obtained from the corn sugar industry, and it binds much like molasses, though with less tendency to bubble. However, it has quite a tendency to absorb moisture, in this respect being more like the beet syrups.

Silicate of soda has not proven successful as a mold or core sand binder on account of the fact that it does not release readily when the metal is poured into the mold, in other words, when it is exposed to heat.

Paste Class of Binder

Taking up the paste class, under flours we find wheat flour the most efficient on account of its large percentage of gluten. Other flour compounds are efficient in proportion to the amount of gluten or sticky material which they contain. Rye flour is never as efficient as wheat flour, and while ground white corn can scarcely be differentiated from wheat flour by ordinary chemical analysis it has practically no binding power. Pea meal, which is used in some sections, has relatively little binding power, and middlings or other similar products are only efficient in proportion to their amounts of gluten of sticky material.

Under starch, we come to a peculiar class of binders. This material is generally used in the uncooked state, in which condition it acts as a paste. All paste, whether flour or starch, binds in a purely mechanical way, that is, the particles of binder are distributed among the sand grains, and ordinarily dry at the point where they are left. If the paste particle happens to bind two grains of sand together it becomes efficient, but if it happens to occur between sand grains in the open spaces it adds nothing to the strength of the core and only tends to close the vent space.

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When starch is cooked or treated chemically in such a way as to make a liquid paste, we then have a binder which behaves more like oil in that as drying progresses it draws back toward the contact points of the sand, thus giving better binding action.

Dextrine is a derivative from starch, having more binding power in the uncooked form than starch.

Oil and Clay in Opposition

In the group of colloids, we find that clay, which is the natural bond of molding sand, plays an important part in foundry practice. In order to develop fully the binding properties of clay, it must have undergone the process commonly known as weathering. It was formerly considered that it was simply the water from decaying vegetation that effected this change, but it is now recognized that bacteria probably play an important part in the changes.

As already stated, there are reactions between these natural binding materials which the chemist calls colloids, and there are also reactions with the various binders used in sand. Flour, starch and dextrine work in harmony with clay. This is also true of most of the water soluble binders, but all of the oil binders act in opposition to clay. The clay first absorbs as much oil as it can, thus taking it away from its legitimate use as a binder, and at the same time the oil destroys the binding power of the clay.

Particularly in steel foundry practice there are some silica sands in which magnesia plays an important part as an active binding material, and there are cases in which milk of lime or other chemical compounds have proven useful, but this group has not received much attention from foundrymen.

We now come to the class of gums. In this class rosin stands by itself. When powdered rosin is mixed with sand as a binder it melts during baking, and flows between the sand grains. Upon cooling, the rosin acts as a binder. For this reason rosin cores are known as hot-soft cores on account of the fact that when the rosin is hot it has no binding power.

If rosin, in a mass, is heated to 645 degrees Fahr. at ordinary pressure, it is decomposed into rosin oil, and rosin pitch. At this temperature the elements which compose the material

rearrange themselves into different forms with radically different chemical properties. Rosin oil is used extensively in the paint trade, and has also been used as an adulterant for core oil. It, however, has a very small percentage of the binding power present in the original material. When a rosin core is exposed to the molten metal the rosin is decomposed as previously mentioned, and the rosin oil passes off as a vapor. Between 80 and 90 per cent of the rosin passes out in this way, and the result is that when rosin cores are used with any metal having sufficient heat to decompose the rosin, easy cleaning conditions prevail.

The vapors from the rosin which condense on the red hot surface of the interior of the casting undergo a second decomposition with the deposition of free carbon, which gives the castings a beautiful, glossy black surface.

The other members of the resin family include all of the varnish gums and the different ambers, but these materials are too expensive for a core binder.

Black Compounds

The so-called black compounds are usually made from rectified pitch which comes from the distillation of coal tar. These tars generally carry about 50 per cent of fixed carbon, or in other words give 50 per cent of very hard coke. For this reason they vary greatly from rosin. During the baking of the core the pitch melts, flows between the sand grains, and binds the material, in this way acting like rosin, but during the casting process a relatively small amount of volatile material is driven off and hence a much larger percentage of coke is left behind. Then, too, this coke has a very hard nature, and frequently makes the core stronger after the metal has been cast around it than it was before it was put into the mold. This coking explains the rebaking effect frequently referred to by foundrymen.

Oil Binders

When we come to the class of oils we encounter two bold divisions. The first represents the drying oils of the paint class. With a true drying oil the binding power is developed,

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not by the evaporation of something from the oil, but by the oxidation of the oil itself so that the binder in the core, after baking, weighs more than it did before baking. The difference, however, is very slight and amounts to an increase of approximately 1 per cent of the weight of the binder, and as in this class of cores the binder is used in the ratio of 40 to 80 parts of sand to one part of oil, it will readily be seen that this increase is so small it would not be noticed in the final results. Also, it is more than counterbalanced by the exclusion of moisture from the sand. With the drying oils, as the moisture is driven out, the oils draw between contact points of the sand, and then harden. The drying of good oil is hastened by adding what is known to the paint trade as dryer. The chemist calls this a catalytic agent or something which has the power of causing changes without itself being changed. For example, certain manganese salts have the power of extracting oxygen from the air and giving it to the oil in such a way as to cause a much more rapid oxidation than could be caused by air alone. With a good drying oil the atmosphere of the oven is a very important factor in the rate of drying, and there must be a positive circulation of a proper amount of oxygen.

It has already been mentioned that linseed oil or chinawood oil head the list of drying oils. The latter also contains a natural drier.

The other bold division of the oil class is found in that type of oil which drys down to a sticky residue that forms the binder. Some of the natural asphalt base petroleum oils of the south and west act in this manner, and in fact any oil from which a certain amount of volatile constituents can be driven out to leave a high melting point tar or pitch, can be classified in this way. We also have in the same class the oils made by dissolving a gum of resin in a petroleum product or neutral oil.

In order to cheapen some oils, many manufacturers introduce a certain percentage of resin dissolved in petroleum oil. Such an addition, however, slows down the drying action of the drying oil as it tends to exclude the oxygen from the oil at the critical point in the drying process, and oil of this kind

really becomes a varnish and it is only by the addition of artificial driers that rapid drying can be effected.

Some of the oils belonging to this latter class will stand more abuse than other core oil on account of the fact that some of the pitches are not broken up readily at ordinary temperatures, and would resist a temperature of 500 or 600 degrees Fahr., finally coking, and still act as a binder provided the temperature does not go high enough to burn them with the oxygen present.

In many cases in the core oil trade the core oil maker has discovered that deficiency in oven design can, to a certain extent, be made up by using certain types of oil binders of the class last discussed, and hence he supplies an oil suitable for these ovens, and later the foundryman improves his oven conditions and then cannot understand why the cores do not come out the same.

With properly designed ovens, and cores made from sharp sand and oil, some one of the high-priced drying oils has always been able to contend with all of the cheaper products of the dissolved gum class, but the sand must be properly mixed, and in many cases iron dryers or core pans are necessary to support the cores during baking. In other words, a given number of cents worth of a high priced oil when properly used will bind more sand than a corresponding value of a cheaper oil.

Core-drying practice, as it exists in most foundries, is simply a compromise, one set of conditions being juggled to meet another.

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Notes on Applications and Characteristics of Cores in Modern Molding

By R. A. Bull, Granite City, Ill.

The word *core* literally means the central or innermost part of a thing. Naturally enough the term when originally applied to molding was intended to designate the part of the mold which was to form that portion of the casting intended to be hollow, but this word as used in the foundry has come to mean much more than that, and today is a misnomer. A core in the accepted, modern, technical sense is any auxiliary part of a mold which is made separately from the main part and which performs the function of helping to shape the casting. As foundrymen we must interpret the word in the way common to the industry. As etymologists we would probably create a more satisfactory term.

A discussion of the part the core has played in the development of the art of molding necessarily must be condensed or become a detailed account of improvement in molding methods extending through generations long since departed. Such a resume might be of historical interest, but is not contemplated in this paper. We are chiefly concerned with the functions and manufacture of cores as they have latterly reduced our molding costs and as they promise further economies.

We may not realize, on casual thought, that the principle embodied in the use of the stop-off core with its almost inexhaustible modifications is the basis for much of the development in the art of molding. The stop-off core could be dispensed with and yet the casting might be molded. The operation is tremendously simplified by its use. Therein lies the interesting feature of the use of cores and the one that has given birth to manifold applications, many of which are of comparatively recent origin.

Given a reasonable number of castings to make from one design, we should bear in mind that in all likelihood the two largest items of expense to us will be the labor of molding and finishing the castings (using the term finishing in its broad sense and not simply as indicative of machining). If a casting is to be floor-molded, unless it is of very plain or peculiarly intricate design, the mold can be made in several ways, one of which may require the use of a three-part flask, another a two-part flask and another a one-part flask. Green sand molding is generally considered as the cheapest means for making the ordinary casting, and yet we find it sometimes to be the most expensive. We must be governed as to the construction of a pattern not simply by the facility with which the facing may be rammed, but also by the ease with which the pattern may be drawn, by the tendency of all parts of the mold to *stay put* during these and subsequent operations, and by the speed with which these operations may follow each other. In such analysis, it should be kept in mind that the total cost of ramming, baking and handling a few cores is but a fraction of that required to tediously manipulate lifting plates or cheeks in the majority of cases.

How Cores Reduced Molding Cost

The writer recalls a casting formed of several horizontal and transverse I-beam members, the total area covered by the flask being considerable. The original method employed in making the mold was by means of a three-part flask, almost the entire mold being made of green sand. It required the skill of five molders and three helpers for two days to make one such mold, and the casting showed the unsightly effects of the impossibility of keeping the cavities in the mold free from dislodged sand. It was apparent that this method of making the casting was very expensive, and lifting plates necessitating the use of several hundred pounds of heavy steel rods were cast and for a time employed, thus eliminating cheeks. This enabled six molders and four helpers to make a mold in one day. After some time the idea of forming the metal between the top and bottom flanges with dry cores instead

of green sand was suggested, and when it materialized, four molders and two helpers were able to make a mold in one day. This method of course necessitated considerably greater cost, and the expense of making one complete set of cores was four times that occasioned by each of the two former methods, but nevertheless representing only one-half of a day's pay for a molder. The top flanges of these particular castings were comparatively narrow and the upper surface of the pattern was almost straight. These conditions lent themselves admirably to the use of covering cores, for which suitable binders were designed, superseding the large and unwieldy copes. The application of covering cores enabled one molder and one helper to make a mold in one day, and raised the core cost to 65 per cent of a molder's wages. A simple calculation showed that the total cost of molding and coremaking for these castings was gradually reduced in the proportion of 6 to 1 and that the use of cores in this development reduced this cost in the ratio of about 4 to 1. Other distinct advantages were secured. The appearance of the castings improved to a marked degree. The finishing cost was correspondingly reduced by 30 per cent, and the overweight of the castings dropped from 10 to 4 per cent. Just half the floor space for molding was required after the covering cores and binders had superseded the cope. Gagger expense was eliminated, and was not to any appreciable extent offset by the use of core rods. This is simply a typical example of the way in which cores may be employed to advantage in a manner entirely apart from the function for which they were originally intended.

Opportunities for Extensive Use of Cores

To make many such castings in this way necessitates suitable core room facilities and systematic means for handling cores. In forming comparisons we should bear in mind that the direct labor of making all cores either by day work or by piece work is in most cases probably not more than one-half the total core room expense, and that in many foundries the indirect labor in the core room is a greater percentage of the whole than the indirect labor on the molding floor. Despite all such allowances, if the general design of the castings lends

itself reasonably well to any such development as has been above cited, great economies are sure to result by advancing the core room to a more important position in foundry operations. The degree to which coring may be largely employed in molding shops must, of course, be governed by the nature of the castings, and this paper might be elaborated by citing many examples without accomplishing any useful purpose. The subject itself is a tremendously important one, but its limitations for profitably extended treatment in a paper are readily apparent. Each foundry must work out its own salvation as prescribed by the designs of its castings, and the amount of duplicate work. Be it remembered, however, that "copeless wonders," as they are occasionally called by molders, while adapted more readily to patterns having narrow straight top surfaces, may be economical substitutes for the customary cope and drag if angles and radii to some extent break up the plane of the mold's upper surface.

Handling and Storage of Cores

A few desirable considerations that should be given to the manufacture and use of cores which can be profitably carried on in an extensive way, may be appropriately presented for discussion. Any system which does not primarily provide for the handling of cores in sets will be found unsatisfactory, save in those cases where molds require very few cores, and where these are of standard design. The confusion resulting from ignorance of the number of complete sets of cores on hand is considerable. This factor necessitates liberal facilities for storage and handling. And since it is decidedly advantageous to handle all cores the least possible number of times, much thought should be given to the expedition with which a core may find its way from the oven to the molder. There are plants where operations are so extensive that cores require handling for considerable distances through several channels. The amount of binders in such cases must be considerably greater than that simply required for withstanding pressures exerted in the mold, and should take into consideration the expense of breakage in handling and the importance of maintaining well-defined edges on the cores. Skill in drying is a

very important adjunct in maintaining ideal conditions in these respects, and is indicated not only by the time required for baking, but by the character and control of the fuel and by the condition of the ovens. It can be appropriately remarked in passing that mechanical stokers adapt the use of coal to splendid advantage for core ovens, which give the best results under pyrometer control.

Consideration of Dry Sand Binders

Any study of sand binders is most interesting and profitable. There is much deception practiced upon foundrymen by purveyors of foundry flours and other binders. Large foundries have conveniently at hand means for safeguarding themselves in such purchases which the smaller shops do not enjoy. Nevertheless, the latter can advantageously use a few simple tests to determine certain essentials. By placing a flame similar to that produced by a Bunsen burner under a refractory vessel containing a sample of wheat flour, the absence after combustion of any residue save a sort of yellowish film on the vessel will quickly convince anyone who has no knowledge of chemistry that there is no plaster of paris or limestone present. An effervescence produced by pouring a small amount of vinegar on a flour sample is evidence that pulverized lime rock or a similar material has been used to defraud the foundryman. Scrutiny as to the arts of the conscienceless salesman is necessary, since it can be stated that materials containing 50 per cent of substances which never saw a wheat field, and which were added solely to swell the mass, have been offered to foundrymen as superior foundry flours.

The presence of sea coal in dry core compound can only be guessed at in the small foundry. Where facilities in the shop are available for making homogeneous sand mixtures, there is no reason for purchasing dry core compound containing any percentage of sea coal, when it is remembered that this commodity can be bought readily at one-fourth to one-fifth the cost of a prepared compound, and that it frequently represents 15 per cent of the mass in the latter. The economy of purchasing separately any amount of sea coal found

advisable to use in mixtures is obvious, given proper mixing facilities.

Wheat flour is a commodity, the price of which has been greatly increased by the European war. It is now one of the most expensive ingredients we may use in our core sand. Rice flour is a substitute which can be secured under present conditions at a much lower price with the best results. Its bonding strength on the sand fully equals that of wheat flour. The use of either rice or wheat flour can be materially reduced in many cases without any bad effects by using cheaper binders to make the core hold its shape in a green condition.

There seems to be no reason for the use of several kinds of binders except as those are required for the two essential functions of keeping the core stiff enough in its green condition to enable handling to the oven and making it desirably hard after being baked, always providing that undesired properties such as affinity for moisture and tendency to volatilize are not present in excessive degree. The strength of pitch which is the basis of nearly all dry compounds, comes into play after baking, and this necessitates the use of another binder as an adjunct. If suitable bonding materials are purchased separately and mixed with the sand thoroughly, pulverized pitch alone can be satisfactorily employed in lieu of dry compounds bearing a trade name. The writer has no quarrel with manufacturers of core compounds, but feels that the cloak of secrecy which is sometimes thrown about these materials can be removed with profit to the foundryman and to the honest dealer in foundry supplies.

Degree of Fineness of Sand Binders

The degree of fineness to which clay, pitch and other binders are pulverized is very important in predetermining the bonding effect of sand mixtures. Any tendency to coarseness, which may be readily ascertained by the use of a few inexpensive screens, is objectionable. The bonding strength of core sand treated with a pitch compound, of which 75 per cent passed a screen of 200 meshes per square inch, has been found to exceed by 15 per cent or more that attained by

mixing with the sand the same volume of an identical compound of which only 35 per cent passed the same screen. The fineness is important from another standpoint. The finer the material the less it weighs per cubic foot within the ranges common to dry binders. The foundryman buys such commodities by weight and generally uses them by bulk measure. While he accordingly uses less binders per unit of bulk measure in his sand mixtures as the degree of fineness increases, the strength of his cores is not reduced, but is indeed actually increased by reason of the better distribution in the mass attained by the finely pulverized bonding agents.

Liquid Binders

There are several liquid binders on the market which are treated by-products of paper mills, and which are preferable to molasses as liquid binders. These are supplied with a desired degree of uniformity impossible to secure in the purchase of molasses from different jobbers. Considering that these binders obtained in the manufacture of wood pulp when mixed with foundry sand will yield fully one and one-half times the strength of molasses sand, it will be admitted that they have an important function to perform in the core room, especially since they may be purchased at prices which compare favorably with that of molasses.

A simple briquette testing machine is an admirable means for determining relative bonding strengths, and the cost of such a machine could be borne by any foundry. The art of using it can be acquired readily by any amateur. A word of caution might be mentioned as to the necessity for identical treatment of briquettes to be comparatively tested.

Use of Green Sand Cores.

Bearing in mind that the cost of cores is considerably increased by the baking process, we may profitably employ green sand cores in many instances. As these comprise a relatively small percentage of all cores made in the average foundry, and as they present few complications or opportunities for novelties in manufacture, it is not thought best to discuss them at length in this paper. Very ingenious arbors have been

devised for supporting the sand in green cores, and for subsequent removal from almost inaccessible parts of castings. Extremely useful applications of green cores have been made to overcome shrinkage difficulties, where the expedients of introducing quickly combustible or easily compressible materials in the interiors of dry cores do not yield the best results. The importance of green cores should not be minimized, but very detailed discussion of them necessarily has more of a local interest than a general one.

Handicap of Pattern Design

A factor which has militated considerably against the more economical use of cores in jobbing shops is the practice that many consumers of castings unfortunately adopt, of providing their own patterns. Users of castings frequently make themselves, or have made, all pattern equipment at the lowest possible cost, irrespective of the number of castings required and the application of simplified molding methods. We may admit that this is a condition difficult for us, as foundrymen, to adjust. I, however, believe that we could, with much advantage to ourselves and to consumers, emphasize this factor more vigorously than we have in the past. It is sometimes quite effective to make alternative quotations on castings to be made from patterns furnished by the foundry.

XUM

Some Remarks Regarding the Permissible Phosphorus Limit in Malleable Iron Castings

By Enrique Touceda, Albany, N. Y.

In response to an invitation from your program committee to contribute a paper for your annual meeting on some phase of malleable iron casting practice, a subject has been selected and conclusions have been deduced from the investigation, which, in view of the non-insertion of a phosphorus limit in the specifications for these castings that have been lately adopted jointly, by your association and the American Society for Testing Materials, I believe will indicate that they have not erred in simplifying the standard to this extent. What has been written may prove not only of general interest to the malleable iron industry, but to those also who have closely followed up the effect of phosphorus in ferrous products.

Having spent the first 10 years of my working life in the manufacture of steel, I come honestly by a bitter prejudice against this element, and while this prejudice, as far as steel is concerned, is still with me as strong, if not stronger than ever, on reminiscing over past experiences and the many cases I can recall, the feeling exists that in numerous instances, mysterious failures in low carbon steel, attributed at the time wholly to a phosphorus content slightly above the bessemer limit, would have been found to have been due to faulty structural conditions, had we at that period been possessed of the knowledge since gained through the use of the microscope.

There is ample proof that when phosphorus is accompanied by carbon in the combined state it has a tendency to embrittle steel in some proportion with increase of carbon. Owing to the familiarity of all with this fact, many have carried their

prejudice so far that they deem it unwise to take any liberties with this element, even in cases where the amount of combined carbon is inappreciable, as in wrought iron or malleable iron castings, and there are still individuals who desire to restrict the phosphorus limit in these two products to less than 0.15 per cent.

Phosphorus Content of Malleable Iron

Until several years ago the writer was strongly of the opinion that no good and dependable malleable iron could be made with a phosphorus content in excess of 0.20 per cent, and this opinion had been strengthened by the examination of many poor samples that had come to hand from various sources. As time passed, however, and the true cause of failure was, through study and investigation thoroughly understood, the fear of phosphorus grew less, and while it is not my purpose to recommend, as a general proposition, that the manufacturer of malleable iron castings should take undue liberties with this element, especially as it leads to no saving in cost—since pig iron with a phosphorus content of 0.18 per cent is as plentiful and as cheap as that containing 0.30 per cent—still there are particular cases where to use a slightly higher percentage than is customary would result in a better product. Just what is meant by this statement will be made clear a little later when we consider the data obtained from the physical tests.

For the purpose of investigating this problem as well as the time at my disposal permitted, and inasmuch as it is an acknowledged fact that the effect of phosphorus in steel is to render it more unreliable under shock than under static stress, I decided to confine my experiments to the testing of specimens dynamically, for the reason that if the metal proved good under such conditions there could be no question as to what would be shown under tensile test. The character of test specimen selected and the method of testing have been described previously in other papers, but for the benefit of those who are not familiar

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with these discussions, I will state that the test bar is wedge-shaped, 6 inches long by 1 inch wide throughout, the dimensions of the base being 1 x ½-inch and of the top, 1 x 1/16-inch.

Testing the Specimen

To test a specimen, its base is securely keyed into a slot in a vise free to rotate in the anvil of a drop hammer, details of which are shown in Fig. 1. The weight then is raised and the free end of the wedge is struck repeated blows; the effect of each blow is to cause the end of the wedge to curl up as shown progressively in Figs. 2 and 3, until finally failure takes place by fracture. The vise and anvil block have been so constructed that the wedge, when struck, receives the full force of the blow without upsetting. To accomplish this, the vise

Table I

Chemical Analysis of Wedges Contributed by Manufacturer A.

	Set No. 1. Per cent.	Set No. 2. Per cent.	Set No. 3. Per cent.	Set No. 4. Per cent.
Silicon	0.800	0.810	0.800	0.800
Phosphorus	0.181	0.252	0.325	0.388
Sulphur	0.099	0.100	0.106	0.100
Manganese	0.284	0.290	0.291	0.251
Combined carbon ...	0.050	0.070	0.050	0.040
Graphitic carbon ...	2.070	1.910	1.940	2.260

had to be so designed that the operator can turn the wedge in such a manner that the weight is always falling on the highest part of the curled end. The tripping pin that releases the hammer is in a fixed position to deliver an initial blow of 70 foot-pounds, but a little reflection will prove that each succeeding blow is greater than this amount. This is due to the fact that owing to the curl of the wedge the weight has a slightly greater distance to fall before coming in contact with it than when the initial blow was struck, coupled with the fact that the maximum effect of the blow does not take place on the section struck, but on the extreme fibers of a section some distance from the former.

Through the courtesy of two producers of malleable iron castings I was furnished with sets of test bars, those from Manufacturer *A* having consisted of 24 wedges. The first six

of this series were cast from a ladle which contained 30 pounds of air furnace iron corresponding to the mixture that was being run in the foundry at that time. The next six were cast from the same ladle of iron, but after an addition of a certain amount of 20 per cent ferro-phosphide had been made; the next six were cast after a further addition of the alloy, and the last six after a still further addition. In this manner four sets of six wedges were obtained, the composition of which differed approximately only as to phosphorus content. At the time when the wedges were made, a ⅞-inch square bar (not exactly square owing to draft) also was cast for transverse test, and the analyses in Table I were obtained from drillings taken from these bars and not from the wedges.

Table II.

Number of 70 Foot-Pound Blows Required to Break Test Wedges Shown in Fig. 4.

Set No. 2. No. of Blows.	Set No. 3. No. of Blows.	Set No. 4 No. of Blows.
37	36	27
41	41	28
41	45	31
42	51	34
42	52	34
57	54	34
Average....43.33	46.50	31.33

Unfortunately, the six wedges belonging to Set No. 1 inadvertently were not sent to me and I have since been unable to secure them, but inasmuch as this set was poured from straight air furnace iron without the ferro-phosphide addition, the omission will in no way affect the conclusions that can be drawn from these tests. That this statement can be made safely will be appreciated by referring to Fig. 4, which shows the curled wedges of Sets 2, 3 and 4. All of these, with two exceptions in Set No. 4, were subjected to 30 blows somewhat greater than 70 foot-pounds each. One of the exceptions broke at 28 blows and the other at 27. After the wedges shown in Fig. 4 were photographed they were again subjected to this test until failure took place, and Table II contains a record of the total number of blows required to produce fracture.

Having described the method of testing, I believe it will be acknowledged that the metal of which Set No. 4 was composed, and which contains 0.388 per cent of phosphorus, is of superior quality and is trustworthy for most purposes. The metal of

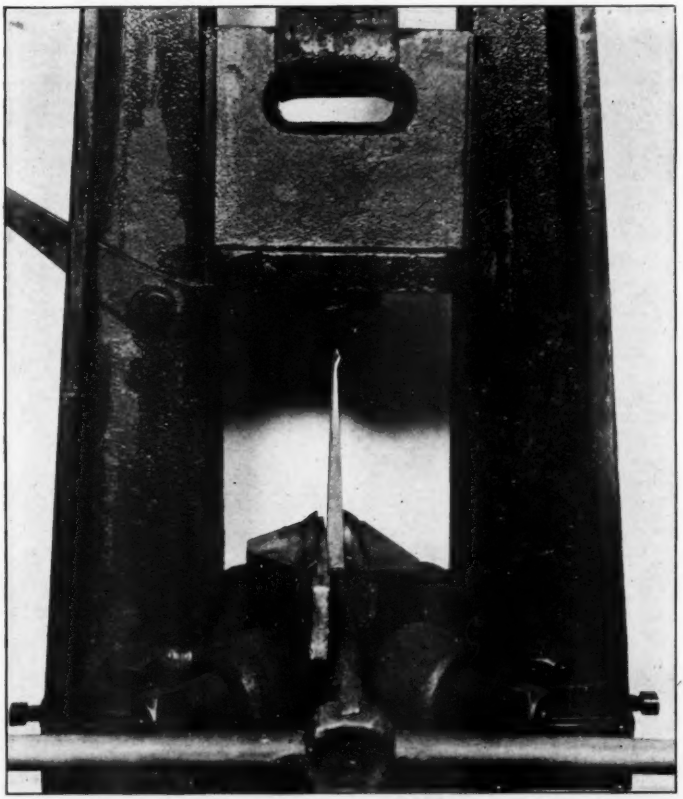

FIG. 1—DEVICE FOR TESTING MALLEABLE IRON SPECIMEN

Set No. 3, which contained 0.325 per cent of phosphorus, is of still better quality and sufficiently high grade to be suitable for any purpose for which malleable iron castings may be required.

Phosphorus exists in iron as phosphide of iron. It unites with iron in definite proportion, which compound in turn is dis-

solved in solid solution in the excess iron. If the percentages of phosphorus in these four sets of wedges be calculated to phosphide of iron, we will obtain:

	Set No. 1. Per cent.	Set No. 2. Per cent.	Set No. 3. Per cent.	Set No. 4. Per cent.
Phosphorus	0.181	0.252	0.325	0.388
Phosphide of iron..	1.086	1.512	1.950	2.328 approximate.

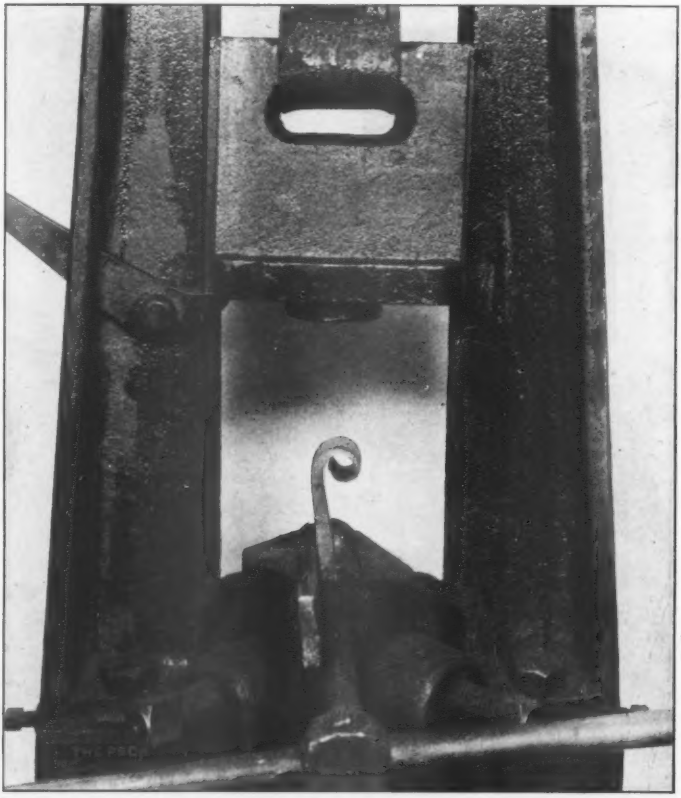

FIG. 2—ANOTHER VIEW OF MALLEABLE IRON TESTING DEVICE SHOWING SPECIMEN PARTLY CURLED

The 7/8-inch square test bars, previously referred to, were cast at the same time and made of the same metal as the four

sets of wedges, and to test these transversely, they were placed on the anvil of the same hammer, on supports 6 inches apart. The following is a record of the number of 70 foot-pound blows required to break them:

Bar No. 1.	Bar No. 2.	Bar No. 3.	Bar No. 4.
Blows.	Blows.	Blows.	Blows.
22	20	15	5

FIG. 3—A PROGRESSIVE VIEW OF SPECIMEN IN TESTING DEVICE WHICH IS FURTHER CURLED AS A RESULT OF REPEATED BLOWS

From these figures it would appear that as the section is increased, the evil effects of phosphorus become more manifest.

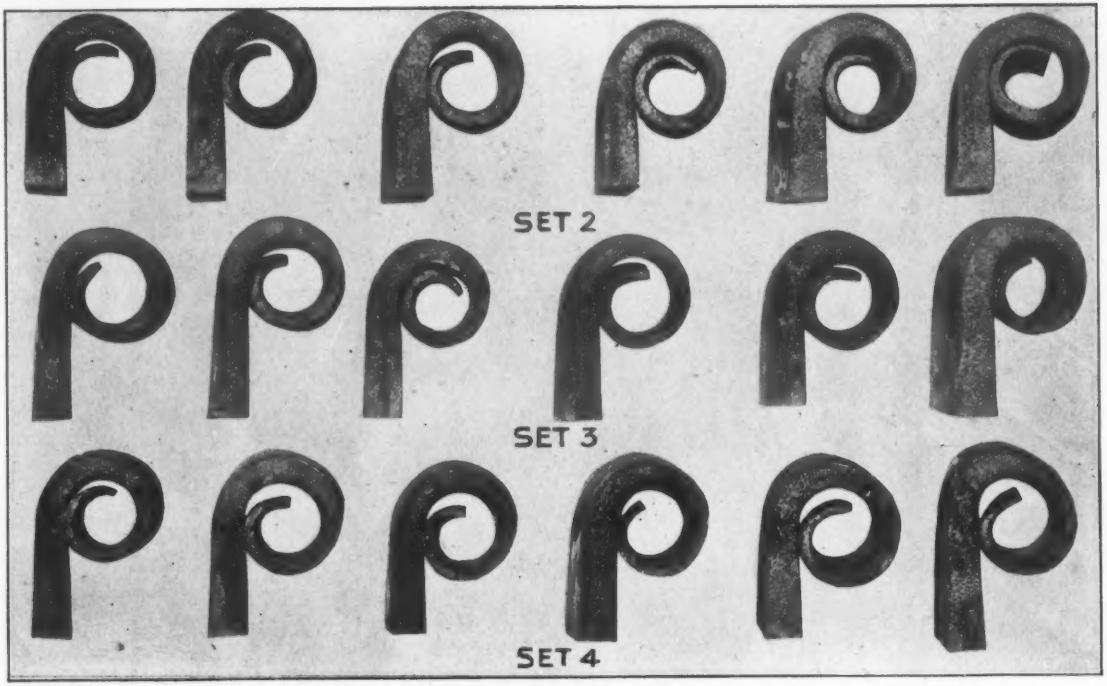

FIG. 4—TESTED WEDGES REPRESENTING SETS NOS. 2, 3 AND 4

However, bar No. 3 was subjected to fifteen 70 foot-pound blows before rupture took place, which for a metal containing 0.325 per cent of phosphorus, or about 1.95 per cent of phosphide of iron, is certainly no mean test. Bar No. 2, containing 0.252 per cent of phosphorus, or about 1.51 per cent of phosphide of iron, required 20 blows to produce failure, a test which I consider indicates superior metal. Fig. 5 shows the fractures of these four bars which indicate the changes in appearance of the fractures with increase of phosphorus.

Those familiar with the appearance of the fracture of malleable iron when tested transversely, know that the part of the bar in compression always shows up white in color for a certain distance below the surface, and with a more or less

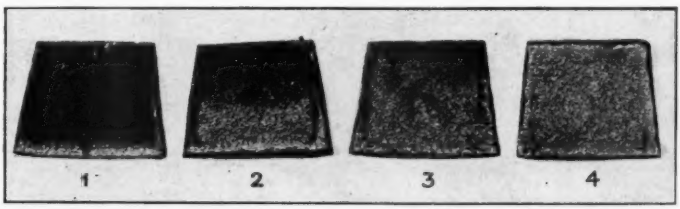

FIG. 5—FRACTURES OF FOUR MALLEABLE BARS WHICH SHOW THE RESULTS OF INCREASING PERCENTAGES OF PHOSPHORUS

granular structure. In Fig. 5 the position of the bars is the reverse of the way in which they were tested, as the white areas represent the compression side. It will be noted that as the phosphorus increases, the amount of white area increases, and in bar No. 4 there is no difference in the appearance of the fracture on either side of the neutral axis.

Investigation of Grain Size

In an effort to discover if the grain size had increased with the increase of phosphorus, a section was cut from each of these bars, which was polished and etched. Careful microscopical examination and a comparison of one sample with the other revealed no particular difference in grain size in any of the samples, though phosphorus is presumed to have this effect.

To avoid making conclusions from one set of tests only, samples were secured from Manufacturer *B*. The phosphorus determination of this series of wedges showed that the amount of ferro-phosphide used was not sufficient to raise the phosphorus as high as I desired for the investigation, and due to this I requested another set which contained more of the alloy.

The first set, from Manufacturer *B*, consisted of 15 wedges, three in each set, which were cast in the manner previously described. The following is a record of their phosphorus content and the number of 70 foot-pound blows required to break them:

Set No. 1.	Set No. 2.	Set No. 3.	Set No. 4.	Set No. 5.
Blows.	Blows.	Blows.	Blows.	Blows.
12	8	8	9	14
10	9	8	7	6
9	9	14	10	8
		Phosphorus.		
Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
0.159	0.169	0.180	0.195	0.220

I subsequently received another series of 15 test wedges and set No. 1, untreated metal, had the following analysis:

	Per cent.
Silicon	0.870
Phosphorus	0.155
Sulphur	0.052
Manganese	0.239
Combined carbon	0.040
Graphitic carbon	2.580

The number of 70 foot-pound blows required to break these five sets of test wedges and their respective phosphorus content follows:

Set No. 1.	Set No. 2.	Set No. 3.	Set No. 4.	Set No. 5.
Blows.	Blows.	Blows.	Blows.	Blows.
6	7	7	6	7
7	8	8	6	4
9	6	6	7	5
		Phosphorus.		
Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
0.155	0.181	0.207	0.235	0.277

It will be noted that none of these sets of wedges furnished by Manufacturer *B* contains as high a percentage of phosphorus as those furnished by Manufacturer *A*. The metal from which these wedges were cast was of poor quality, but the practice

of this shop has since been corrected. Unfortunately, the wedges were not cast as well as they might have been, which also may account for some of the variations in the results. When a test bar is subjected to such a severe test as the one used in this instance, any surface defect on the tension side is bound to influence the result to the disadvantage of the test bar.

From a consideration of the facts before us, it would appear that when the amount of combined carbon is very low, the evil effects of phosphorus are slow to make themselves felt, and it requires a substantial increase in this element before a corresponding change in physical characteristics can be noticed.

Patterns occasionally are delivered to casting plants from which it is almost impossible to obtain satisfactory castings free from shrinkage in parts that should be very strong, in spite of the generous use of heavy risers and chills. A shrink results from failure to supply liquid metal to the mold so that as the shell of the casting gradually builds up with solid metal, liquid metal always will be present to fill up solidly the last void in the casting. There are many circumstances that operate to make difficult, or entirely prevent, complete solidity in the average casting. A discussion of these is unnecessary to make clear the point I desire to make, namely, that of two furnace mixtures, one much more fluid at the same temperature than the other; the former will produce castings from the same pattern with less shrinkage than the latter.

I have examined castings that have failed and have tested pieces cut from different portions of these castings to prove that these consisted of metal that was as tough and strong as malleable iron can be made, and that failure resulted because of local weaknesses due to unsoundness from shrinkage.

Unfortunately, according to present practice, the conditions that yield the toughest and strongest malleable are those that have a tendency to produce sluggish metal. Phosphorus being constant, carbon is that element in air furnace iron that contributes more fluidity than any other, but experience has demonstrated that among other accompanying conditions, the

lower the carbon approaches that point where the hard carbides in the white iron can still be broken up in the anneal, the stronger and tougher the finished product.

If the facts as I have stated them are correct, then I would like to submit this question for your consideration: In castings made from patterns poorly designed and which the manufacturer is not permitted to alter, or in complicated castings made from patterns that have been designed as well as skill can suggest, is it better practice to have certain parts of the castings strong and solid, and other parts weak and unsound, or is it better to effect a compromise and have the castings of fairly uniform strength and solid throughout? There surely can be only one answer to this question. It is wrong to assume that the physical properties of a metal, as shown by tests, on test bars easily cast sound, are representative of the quality of the metal in any part of a casting.

In my opinion, the manufacturers who are producing the best product are the ones who are constantly aiming to increase the strength of the weakest parts of their castings, the parts in which, due to certain laws, unsoundness is liable to occur, unless new laws are invoked to make these inoperative.

In conclusion, I will acknowledge that the experiments made are few in number, but the paper is not presented as one that has treated the subject in any other than an introductory manner. I hope that others will follow this particular line of investigation so that it can be determined definitely just how far it is safe to make use of phosphorus and to ascertain whether thickness of section is a factor entering into the problem.

XUM

Discussion—Permissible Phosphorus Limit in Malleable Castings

THE CHAIRMAN, J. P. PERO:—Gentlemen, this is one of the subjects that means much to some of us, particularly those who are engaged in the lighter lines of work. Our losses are heavy and this is a paper that should have free discussion.

MR. STANLEY G. FLAGG, 3RD:—Do silicon and carbon have any bearing on the amount of phosphorus?

MR. ENRIQUE TOUCEDA:—The silicon and carbon exert no influence on the phosphorus, as far as I have been able to discover.

MR. L. E. GILMORE:—I would like some information on the results of an increase of 0.10 per cent of phosphorus.

THE CHAIRMAN:—It would be exceedingly difficult to make a test to increase the result of that increase in phosphorus. We run our furnace on malleable for ranges. Our losses frequently are pretty heavy, but we have increased the phosphorus from 0.175 to 0.28 per cent, without noting any appreciable difference in the strength of our iron. I would not say that an increase of 0.10 per cent in phosphorus would increase the fluidity a fixed amount, but a reduction in fluidity will be shown in the increased losses.

MR. ENRIQUE TOUCEDA:—I have never measured the increase in fluidity that would be imparted to white iron by 0.10 per cent of phosphorus. Approximate results can be made by the use of a pattern that would be very thin and long, say ¾ x 3/32 x 18 inches. If the flask was so placed on the floor in each case that the mold was perfectly level, and all other conditions as near uniform at each trial as possible, the fluidity could be measured by the distance the metal ran in the mold, but such tests are hard to make for obvious reasons, and I have lacked the opportunity and time to make them.

The Evolution of the Malleable Iron Process

By J. P. Pero *and* J. C. Nulsen

As a rule, the changes taking place around us are so slight that they cannot be noticed from day to day, and it really takes a review of years to show what has taken place.

The process of making malleable iron was slow in entering into a transitory stage, but once started, it gained headway and we doubt if any other industry has taken so large a stride in the right direction as that of the manufacture of malleable iron in the past few years. In fact, the change has been so rapid that we believe very few have kept sight of it and really know how much more ductile and strong the malleable iron of today is than that made 25 years ago.

Within a quarter of a century, pig iron was bought by fracture almost entirely. The blast furnace man got some idea as to the silicon content of his iron by the appearance of the fracture; that is, if it was heavily mottled he assumed it was high in silicon, and if the fracture was white it was supposed to be low in silicon. He paid little attention to the other elements, such as manganese, sulphur and phosphorus, and today we know that he was not always right in his assumptions as to silicon, for an iron higher in carbon than another will show more mottles even with the same silicon content; therefore, he was dealing with two variables, where he figured on but one.

In the old days, pig iron was graded by number, from No. 1 to No. 6. The irons showing the whitest fracture were graded No. 6 and were supposed to be the lowest in silicon.

How the Malleable Mixture Was Made

The white iron mixture from which malleable iron was made was arrived at in a very crude way. The method followed by some was rule-of-thumb, which consisted of trying

to have the initial charge average 3.5 on the basis of pig iron grading. For instance, if it was desired to figure the charge for a 10-ton heat, the procedure would have been as follows:

The sprue and scrap might be considered as equivalent to No. 6 grade pig iron. Then if 10,000 pounds of sprue and scrap were used, 9,000 pounds of No. 1 pig iron and 1,000 pounds of No. 4 pig iron, the average grade of the heat would be 3.65, which for this case might have been deemed near enough to be satisfactory.

Some manufacturers did not even use an empirical formula such as this to guide them.

It is really to be marveled at that some of the iron made at this time stood up as well as it did. However, plenty of bad heats were turned out, even when the initial charge was as desired (around 3.5) and as a whole, the iron of this period varied greatly in quality and was not reliable. This gave rise to a desire to secure some means of betterment, and chemical analysis was suggested.

The second period dates back about 25 or 30 years, chemical laboratories having been introduced into a number of plants from 1885 to 1890. Pig iron then could be bought by analysis as well as by grade. This resulted in the elimination of the empirical method of figuring charges and the adoption of the practice of obtaining the percentage of silicon in the initial charge.

Importance of Phosphorus and Sulphur

But even after the establishment of chemical laboratories, bad malleable iron continued to make itself manifest from time to time. The principal difficulty was that the chemist did not know just what elements caused the trouble, and those that he did analyze for he considered in the wrong light. For instance, many chemists thought that silicon was the main factor to watch while carbon was seldom considered. We know now that the silicon content has an important bearing, but that the determination of silicon without at the same time knowing what the carbon content is, gives almost useless information.

Then again, chemists knew that phosphorus and sulphur were important factors in determining the quality of steel, so they proceeded to analyze and restrict it in malleable. Here again the sulphur content is uninteresting unless we know the manganese content, and we are just recently beginning to believe that phosphorus has needlessly alarmed us, when present in malleable iron.

From this brief review it is apparent that the success of the chemical laboratory, as at that time constituted, was doomed to failure from the very outset. Poor iron still persisted and people concluded chemical analysis was no help, and in many plants it was abandoned.

However, the need for improvement began to be felt more and more, and after several years malleable iron manufacturers began to take up chemical analysis again, as they felt that perhaps continued study along this line might reveal points on which they previously lacked knowledge.

From 1895 to 1900, many malleable plants again equipped chemical laboratories, doing their best to solve some of the problems which confronted them, but they continued to look at the chemical analysis of malleable in the same light as that of steel, and it was this fact more than any other that prevented the discovery of the main difficulties. The different elemenrs in the iron were considered independently as to the effects produced and the possibility of one element modifying or changing the effect of another was not considered.

Steely Iron

For instance, one of the most perplexing difficulties encountered was the occasional appearance of what malleable iron men term *steely iron*. This was an iron which showed a white, steely fracture after being annealed and remained in this state even after having been re-annealed. Such iron usually shows a high tensile strength, but is inferior when tested transversely, and its ductility is almost *nil*. This iron was obviously unsuited for railroad castings or any castings subjected to shock and for this reason was a "Sword of Damocles" over the head of the malleable iron trade.

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This iron was analyzed and was found to be low in silicon and for a time *steely iron* was supposed to be the result of allowing the silicon to get below a certain limit.

Just about the time malleable manufacturers were congratulating themselves on the fact that the cause of *steely iron* had been found, some one submitted a sample of *steely iron* with a silicon content of 0.94 per cent and again all hopes of arriving at the correct solution were shattered. This, however, was not the only trouble.

The general practice in the malleable iron industry at that time was to analyze for carbon, silicon, manganese, sulphur and phosphorus. It was considered that all carbon present in the iron after annealing was in the temper graphite form and, therefore, a great many chemists analyzed the iron on the basis of total carbon.

We now know that this method was wrong, but the fact that it was followed resulted in many perplexing problems.

Malleable iron of inferior quality sometimes was obtained, but when analyzed, it showed nearly the same chemical contents as that of excellent quality. This obviously proved puzzling, and the determination of the cause of poor iron seemed hopeless.

Associated Effort Among Malleable Men

This state of affairs is representative of conditions up to less than 10 years ago, when some of the leading manufacturers of malleable met to talk over the situation. They feared that the poor malleable which was made from time to time would slowly but surely hurt the industry and prejudice the users, especially railroad men and implement manufacturers, against it. It was finally decided that inasmuch as no scientific research had ever been attempted, they would induce some eminent metallurgist to undertake this work and see if he could not help them. Such a man was finally found and the fact that the decision and choice of this body of manufacturers was a happy one, is proven by the wonderful results that have been obtained.

Hidden mysteries have been revealed. We have learned that *steely iron* can be made with the silicon high as well as

low, because carbon also was found to be a factor. If the carbon is below certain limits it will stay in the combined state as pearlite, and cause steely iron, no matter how high the silicon content may be. On the other hand, our former assumption that too low a silicon content caused steely iron also was correct, and iron too low in silicon cannot be forced to give up the carbon it holds in combination, no matter what the carbon content may be.

In like manner we have learned that sulphur and manganese are just as closely related. Formerly it was believed that if the sulphur was below 0.05 per cent it could not hurt malleable, because it did not hurt steel. We used to think that an iron running 0.02 per cent in sulphur was better than that analyzing 0.06 per cent. As a matter of fact, if the manganese in these two irons is 0.24 per cent, the one containing 0.06 per cent sulphur is the better iron of the two.

Phosphorus Limitation

Recently, also, there has been some doubt as to whether or not the limitation of phosphorus to 0.225 per cent was not a needless precaution. In the light of these last few remarks, we can see that the malleable iron specifications used in the past did not in any way accomplish their purpose. That is, they did not protect the buyer from poor malleable or assure securing a good quality.

Nearly all the old specifications contain a clause that malleable iron shall not contain over 0.05 per cent sulphur or over 0.225 per cent phosphorus. Nothing is said about the manganese content and, therefore, limiting the sulphur to 0.05 per cent is in some cases the means of securing bad iron rather than good. For instance, iron with a manganese content of 0.34 per cent would be of inferior quality with a sulphur content of 0.05 per cent, but it would be satisfactory if the sulphur was 0.085 per cent. If a limit is placed on sulphur, the manganese content also should be limited, but it might preferably be stated that the sulphur content shall be from one-third to one-fourth the manganese content, as there is no temptation to raise either one of these elements above a reasonable limit.

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The same holds true with reference to silicon and carbon. It is meaningless to limit the percentage of the one without assigning the proper corresponding value of the other.

Perhaps the biggest improvement brought about by this scientific work has been the introduction of misroscopic investigation as well as chemical and physical analyses into our practice.

Chemical analysis serves to show what is in the iron, but as stated before, this knowledge is not always sufficient, as much depends on the state in which the elements exist, whether the carbon is combined with the iron to form pearlite and cementite or whether it is in the free state, as temper carbon, all of which is clearly brought out by means of the microscope.

What the Microscope Has Done

The microscope reveals whether a piece of malleable has been annealed too short a time or at too low a temperature; whether the annealing temperature was too high, or if the cooling was too fast. These points were questions of doubt until this research was undertaken.

The practice in many malleable plants today is to cast three types of test bars from each heat, one set ¾-inch square and 14 inches long for making a transverse test; another set of ⅝-inch round test bars for making a test of tensile strength and elongation, and one set of wedge-shaped bars for making a dynamic test. The latter bars are 6 inches long and 1 inch wide. They are ½-inch thick at the base and taper to 1/16-inch in thickness at the point. This wedge is held upright under a drop hammer delivering a 70-foot-pound blow and is gradually curled up with each successive blow. This last test is also a direct result of the research work undertaken and is one of the most severe and exacting to which malleable cast iron has ever been subjected. All of these tests have values assigned to them, to which the iron must conform before it is passed as 100 per cent in quality.

If for any reason they fail, sections of the bars tested are polished and etched and examined under the microscope, which in connection with the chemical analysis at once indicates the cause of failure.

This method of control, carried on day by day, explains why the iron now made is so much better in quality and runs so much more uniform than that made 15 or 20 years ago—or five years ago for that matter.

A few years ago, when we first began to understand the relations and significance of the elements present in malleable and to change the white iron mixture somewhat to conform with this knowledge, we thought wedges that stood seven 70-foot-pound blows represented good iron. In a short time the quality of the iron had so far improved that we decided on 10 blows to represent 100 per cent quality and about a year ago we had to change this so that 20 blows represented 100 per cent quality; but still we are not high enough, as we are now making iron that will easily average 35 blows. We really do not know just how far this improvement may go, as we have tested bars that stood 108 blows, and this serves to illustrate the possibilities of improved malleable iron practice.

Tensile Strength of Daily Heats

In like manner the tensile strength of the iron has improved. It can be stated safely that the average tensile strength of malleable made 15 to 20 years ago was from 38,000 to 40,000 pounds per square inch. Today the iron made at some plants will average 50,000 pounds per square inch and we have broken one bar that tested 71,500 pounds per square inch.

To show that with the facilities now at our command, iron such as this can be made day in and day out and is uniform, we are including a run of 21 consecutive heats from one furnace, showing the tensile strength of the iron produced.

The omission of the dates of several of the working days in the following was due to the idleness of our plant which was operated only four days per week during this period:

Date, 1915.	Tensile strength, pounds per square inch.	Per cent elongation in 6 inches
1-11	59,600	7.55
1-12	62,100	7.81
1-13	61,500	7.29
1-14	62,500	7.81
1-18	60,500	6.24
1-19	45,500	4.16
1-20	56,400	10.41

Date, 1915.	Tensile strength, pounds per square inch.	Per cent elongation in 6 inches.
1-21	53,300	5.21
1-25	59,400	5.21
1-26	60,200	13.58
1-27	63,000	12.24
1-28	56,600	5.21
2- 1	57,000	5.73
2- 2	57,000	9.37
2- 3	63,000	9.37
2- 4	63,800	10.94
2- 8	60,000	8.85
2- 9	58,600	10.94
2-10	60,100	10.94
2-11	61,200	8.33
2-15	61,500	5.21

We believe that when the properties of such iron as this are compared with that of malleable iron made 25 years ago, our fellow-workers in the malleable iron industry will agree that we have made progress of which we need not feel ashamed.

While malleable manufacturers are to be congratulated upon the progress made in recent years, they must not be satisfied with the results obtained, but must continue to advance.

A Lesson From Steel Casting Manufacturers

In this connection we may profitably take a lesson from the steel casting manufacturers who have been perfecting their product while we have been almost at a standstill. As a result, the steel foundries are now supplying castings, which from the nature of the service required of them, would be far more satisfactory if made from a high grade malleable iron. Unfortunately, however, too many of our malleable manufacturers are still satisfied with the production of iron of inferior quality and are not taking advantage of the knowledge gained and results obtained in securing uniformity and high quality in malleable iron. This attitude on their part is detrimental to the entire industry and makes it possible for the steel casting to replace the malleable, for when a lot of malleable castings fail in service, it is not the individual casting that is condemned, but malleable iron generally is considered unfit for the purpose. As a matter of fact a large part of the steel castings used,

especially in railroad work, could be replaced by malleable of good quality, both from the standpoint of economy and adaptability.

This may seem to be a strong statement, but it is an incontrovertible fact that for certain classes of work, malleable iron is indisputably superior to steel. Castings subjected to shock or to dynamic stresses, if made of a good quality of malleable iron, will outlast steel or any other ferrous metal, as malleable iron is not as susceptible to fatigue failure as cast steel, owing to the difference in structure of the two materials.

Steel Versus Malleable Iron

Steel is of a highly crystalline nature which is practically uninterrupted throughout its section. The basic structure of malleable iron also is crystalline, but its structure is not continuous, as in steel, but is interrupted or interwoven by particles of temper carbon. Ductile materials such as cast steel and malleable iron are weaker under shear than under tension and will fail in shear whether the force applied is tension or compression.

When the applied load exceeds the elastic limit, the crystals begin to slide over each other, the amount of such slipping or sliding corresponding to the permanent deformation received. As these crystals slide, the infinitesimal irregularities on their surfaces interlock, which increases the friction between these two particular crystals, bringing them to rest and starting the slipping between adjoining crystals. This motion continues across the section of the metal in question until the force applied has become so great that the weaker crystals part, intensifying the stress on those remaining when the next weaker crystals part, and so on until complete failure occurs.

The surfaces over which these crystals slide are sometimes called *slip planes* and since the crystalline nature of steel is practically uniform and uninterrupted, it is an easy matter for these slip planes to extend themselves across the section of steel in a continuous, though irregular line, causing cracks and failure.

Malleable iron starts to fail in the same manner, but before more than one or two adjacent crystals have failed, the

incipient fracture will have run into a temper carbon spot. These temper carbon spots usually are located at the conjunction of three or four crystals, so that there are three or four paths along which the fracture may continue and the probability is that the one serious crack will break up, taking three or four of these available paths. These new paths, in turn, run into carbon spots, regardless of whether the smaller fractures are still further broken up. In this way the advance of one large serious fracture is prevented from working straight across the section of metal.

Failure Due to Fatigue

It is hoped that we soon may learn more about fatigue failure and establish beyond question the reason why malleable iron is less susceptible to this than steel.

Malleable iron has a further and very important advantage over steel in the soundness and solidity of its sections, provided care is taken to eliminate shrinkage spots. Malleable is cast at a lower temperature than steel and hence it is free from occluded gases which cause blow-holes and unsoundness.

Soundness of section, coupled with the fact that the ratio of ultimate strength to the so-called elastic limit of malleable is much higher than the ratio of ultimate strength to elastic limit in steel, should justify a much lower factor of safety in the design of malleable, than would be permissible in cast steel, as the allowable working stress of malleable is about 10 per cent higher than that of steel.

As an illustration we will assume that the ultimate strength of cast steel is 65,000 pounds per square inch and the elastic limit is quoted at 35,000 pounds per square inch. Many malleable plants today are producing iron with an average ultimate strength of 50,000 pounds per square inch, which, while lower than the ultimate strength of steel at 65,000 pounds, still has an elastic limit of approximately 38,000 pounds per square inch or about 8 per cent higher than that of steel. Since in the design of castings it is the elastic limit and not the ultimate strength which is considered, it would seem that the facts, as stated in connection with the superior soundness and freedom from blow-holes of malleable castings, should be ample justification for

using a lower factor of safety in arriving at the working stress to be used.

Malleable iron has greater rust-resisting properties than any of the other ferrous metals. Therefore, for use in railroad, implement, and other work subjected to corrosion, malleable cast iron is to be preferred to cast steel or gray iron.

Perhaps in this lengthy dissertation we have gone beyond the confines suggested by the title of this paper. If so, let us plead in extenuation our interest in the malleable iron industry, our desire to see a much abused metal (chiefly so through the ignorance, or carelessness bordering upon dishonesty of too many of the producers of malleable iron) given its rightful position in the engineering world. An earnest hope is expressed that this paper may awaken an interest in producers of malleable iron castings which will tend to secure the highest possible quality in one of the most useful of the ferrous metals.

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An Outline to Illustrate the Inter-dependent Relationship of the Variable Factors in Malleable Iron Production

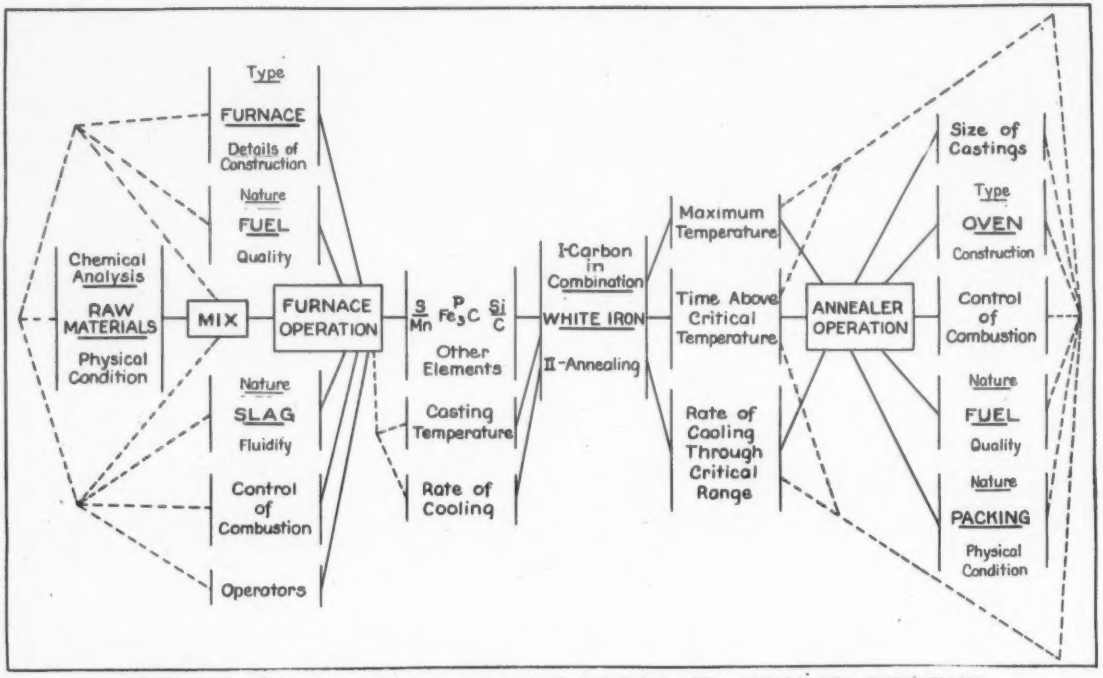
By L. E. Gilmore, Baltimore.

The accompanying outline may be useful as a guide for systematic study and research in malleable iron. A definite outline for study of any subject is a time-saver. When the whole subject is summarized in a page, giving as it were, a bird's-eye view, the influence of each detail on the whole is more quickly grasped, and the inter-dependent relationship of the various factors affecting the product is more readily understood.

In addition, this outline may be used to assist in assigning causes for defective product, as, by first having in outline the various items that may be the cause for defects, we can test and reject one after another and finally reach a true conclusion. Instead of this method, we so often see a cause hastily assigned which, while plausible at face value, proves utterly erroneous if subjected to the several tests now available in chemical and microscopic analyses.

Requisites in Production of Malleable

In the production of malleable, there are two requisites: First, the carbon of the white iron must be in chemical combination, and in such combination that it is annealable, and second, the annealing must be such as will dissociate the carbon in combination, as precipitated free carbon. On the other hand, these two requisites may be expressed in the one statement, that the white iron must be of such microscopic structure that proper heat treatment will precipitate the carbon present in the form of temper carbon. All the variables preceding and during casting must be manipulated to attain the first mentioned condition and all the variables of the



CONTROL CHART OF MALLEABLE CAST IRON MELTING AND ANNEALING OPERATIONS

annealing operation must be regulated to produce the second requisite. Starting, then, with these two requisites as a basis, the outline works from the center backward, so to speak, to the raw materials, and forward to the finished product.

For the production of a white iron with carbon so combined as to properly anneal, the outline shows three main divisions directly responsible for the condition of the carbon; the chemical analysis or inter-dependent relationship of the chemical elements present, the casting temperature, and the rate of cooling.

Taking into consideration the last two divisions, other variables being constant, the higher the casting temperature, the greater the percentage of combined carbon. Likewise, the faster the rate of cooling, the greater the percentage of combined carbon. The casting temperature is largely determined by both furnace operation and length of time of holding in ladle after tapping. The rate of cooling may be modified by a number of factors such as thickness of section of casting, time of dumping of molds, artificial chills and casting temperature. The higher the casting temperature, the greater the rate of cooling.

Chemical Analysis and Microstructure of White Iron

From a metallurgical point of view, of still greater importance than the casting temperature and rate of cooling, is the chemical analysis and microstructure of the hard white iron. The condition of the carbon is largely determined by the inter-dependent relationship of the various elements present—the carbon-silicon relationship, the manganese-sulphur proportions, and the effect of any other elements which may be present. Other conditions being constant, the proper condition of combined carbon may be secured by widely varying percentages of silicon, provided the carbon is correspondingly reduced as the silicon percentage is increased. Likewise, black heart malleable may be produced from white iron of varying percentages of sulphur, provided the manganese is correspondingly manipulated. In experimenting with the addition of chemical elements not so commonly met in malleable, and even with increases of the elements usually present, the investigator may

easily be misled into false conclusions unless every detail is carefully taken into account. For instance, the alloy used to add a certain element to the mix may contain a sufficient percentage of another element so that the effect produced is due to the second element rather than to the first. Certain ferro-alloys have sufficient carbon to gray the white iron, irrespective of the effect of the other elements present in the alloy.

The next step back toward the raw materials is furnace operation. This operation is dependent upon a number of variables, five of which will be considered: First, type of furnace and details of construction, (these might be considered constant, after once adopting a certain type); second, kind and quality of fuel used; third, nature of slag; fourth, control or lack of control of combustion; fifth, the men in charge of the furnace operation.

Types of Furnaces Used

The following types of furnaces have been used for producing malleable: Crucible, cupola, air, open-hearth, converter, electric, duplex, or combinations of two of the foregoing types. The type of furnace is of utmost importance, and the use of a certain type imposes rigid limits on the chemical composition requisite for the successful production of black heart malleable. In the cupola furnace using the average coke on the market, the molten iron as it comes in contact with the coke, absorbs both carbon and sulphur. This immediately determines that with high carbon and high sulphur, we must have low silicon and high manganese. On the other hand, in the other types of furnaces, more leeway is possible, especially in manipulating the percentages of carbon and silicon. However, even in these types, since sulphur and phosphorus are usually changed comparatively little from the mixes, the furnaces limit the percentages of manganese, sulphur and phosphorus, while allowing greater flexibility in percentages of carbon and silicon.

Not only has the type of furnace a predominating influence on its operation, but details of construction, which may be varied, place limitations on methods of operation. For example, the air furnace may be arranged for natural draft, or for

forced draft under the grates, with or without an auxiliary air supply over the front bridge. Each of the infinite variety in details of construction of the different types will have its modifying influence on furnace operation.

Certain details of construction determine the nature of the fuel used. Cupolas have been equipped to burn coke, coal, or oil. Open-hearths may be fired with producer gas, natural gas or oil. The air furnace usually burns coal, but could be arranged to be fired with powdered coal, oil, or gas. Crucibles may be heated by nearly all fuels, while converters require no fuel at all, unless the cold charge be melted in the converter prior to blowing.

Quality of Fuel Used

Not only the nature, but also the quality, of the fuel, greatly affects the furnace operation. A coke too high in ash and sulphur might make impossible the production of good malleable in a cupola. In the air furnace, a high fusible ash coal might present great difficulties. The amount of heat energy available and the speed with which it can be developed and applied in useful work of melting, are factors entering into the choice of fuel and operation of the furnace.

Another important factor in furnace operation is the nature and condition of the slag. The retention or loss, and the speed of elimination of certain chemical elements, may be largely dependent upon the slag. A basic slag would be required to reduce sulphur and phosphorus. The fluidity of the slag is of the greatest importance. In cupola operation, a too viscid slag may bring disaster to the heat through clogging. In the air furnace and open-hearth, the presence of considerable amounts of basic materials such as iron oxide or lime will make a fluid slag difficult to skim and one that rapidly removes silicon and manganese from the molten metal.

Control of Combustion

The next item noted in furnace operation is control of combustion. The method employed is determined by the various factors already mentioned, such as type of furnace, details of construction, nature and quality of fuel, and in addition, skill of operators.

Whether or not all other factors are favorable to the production of best quality, human nature has the final word in furnace operation. Under certain methods of operation some men may produce a quality or iron impossible for others under like conditions, due, naturally, to the differing natures and idiosyncrasies of men. Harmony and co-operation between members of an organization have a profound influence on efficient furnace operation. So the human factor assumes an importance quite as great as any of the other variables with which we have to deal.

The whole subject of furnace operation may be summarized in two aims; that of melting the iron in the shortest possible time at least cost, and that of producing an iron hot enough to pour the work successfully.

Having settled on the type of furnace, and details of construction being fixed, the question now is, what mix will produce the analysis of best composition. Here again the mix is dependent upon the method of operation or *vice versa,* and very probably both may be dependent upon materials available.

The Ideal Mixture

The ideal mix is that which will produce, under the conditions of furnace operation, the desired composition in the melted iron as soon as the iron is hot enough for pouring. Malleable mixes are commonly made up of one or more of the following irons: Pig, white iron such as sprues and scrap, annealed scrap, steel, wrought iron and gray iron scrap. The making of a good mix is not as simple as it might at first appear. To make one properly, practically every item so far considered in this discussion must be taken into consideration. First, the chemical composition required to produce the desired quality of white iron must be known. Then, the losses or increases in each element due to furnace conditions and methods of operation must be discounted. This gives the desirable composition for the mix, which must then be approximated as closely as possible from the materials available. The amount and nature of scrap that can be used will depend largely upon its own chemical composition and that of the various grades of pig

available. For example, the use of a high carbon pig such as charcoal, would carry more low carbon material in the shape of steel. The point to be kept in mind is to mix so that all the elements will be in proper proportions—to mix with all elements in mind and not specifically for one element.

Physical Condition of Scrap and Pig

Likewise, the physical condition of the scrap and pig is a variable that has an important bearing upon the use of these materials. These physical variables are such as size of pieces to be melted, and the condition and amount of surface exposed to the fusing action. Material such as sand-coated pig requires greater length of time for melting. The more chunky the pieces of metal (since less surface is exposed to the heat) the longer the time required for melting. As the chemical composition approaches pure iron, the difficulty of fusion increases. On the other hand, very small pieces of metal which offer large surfaces may be detrimental when badly rusted. This rust, as well as all the loose sand charged with the iron must be taken care of in the slag.

Thus it is clear that factor upon factor act and react, one upon another, and each must be considered in its various and variable effects. At the same time, all factors must be taken into consideration as a whole.

Importance of Heat-Treating or Annealing

Having once produced a satisfactory white iron with all the elements in such proportions that the carbon may be properly precipitated by annealing, there still remain the variables of the heat-treatment to make or mar the product.

The essentials of the annealing operation are: First, the maximum temperature attained; second, length of time held above the critical temperature; and third, the rate of cooling through the critical range. The thickness of castings and nature of packing used are variables which modify the three main essentials.

As in the case of the melting furnaces, the type and details of construction of the annealing furnace are mechanical features that have a great bearing on the production of desired quality.

The annealer may be of a muffle type, or open to the direct action of the flame. Various fuels may be used, as anthracite or bituminous coal, powdered coal, oil or gas. The aim in the construction of the annealer and in the application of fuel, is to furnish a means for rapidly heating the castings in all parts of the oven to as nearly a uniform temperature as possible, and then maintaining this temperature a suitable length of time. Most ovens in actual use fall far short of this ideal, and the fuel, its quality and the operation of the furnace, are of vital importance. In most cases certain parts of annealers reach high temperature hours ahead of other parts, and because of this, it is important to pack the oven so that the castings of greater thickness will receive the greater heat or be held a greater length of time at an annealing temperature.

Variables of Annealing Operation

The variables of the annealing operation are inter-dependent just as are the factors for producing the white iron. For instance, within limits, an increased maximum temperature and shorter holding time may accomplish the same result as a lower maximum temperature with a longer holding time. The use of certain packing materials, or the fineness of this material, may impose a condition of lower temperature. Annealing in an oxidizing, neutral, or reducing packing or atmosphere, will materially affect the toughness of the casting. The rate of cooling through the critical range may make or mar an otherwise perfect material. And so it goes.

The successful and economical production of best quality malleable iron is impossible without a comprehensive grasp of the fundamental principles underlying the actions and reactions of the various factors of its manufacture. Without such knowledge, only by chance will good quality be attained. Scientific control is essential.

While no attempt has been made in this outline to present new knowledge of malleable, it has been the desire of the writer to present the subject so as to summarize the relationship of the variable factors, and to emphasize the interlocking dependence of their relations.

Discussion — Inter-dependent Relationship of Variable Factors in Malleable Iron Production

MR. A. O. BACKERT:—Mr. Gilmore, in discussing furnaces, referred to the duplex type. I would like to know to what extent the duplex process is applied in malleable practice. I would also like to know whether the electric furnace and duplex furnace can be operated together in actual practice?

THE CHAIRMAN, MR. J. P. PERO:—Has anyone any information to offer on the questions asked? Mr. Gilmore, can you tell us?

MR. L. E. GILMORE:—I do not know to what extent the duplex furnace has been used in malleable practice. I believe something has been done with it by the National Malleable Casting Co. Perhaps some member of the National Malleable company may be here and can tell us the results of their experiments.

MR. A. O. BACKERT:—I know that all the malleable men are watching the development of the electric furnace. Is there any economy in melting pig up to a certain point and then pouring it into an electric furnace for final refining? I would like to know if that is feasible.

THE CHAIRMAN:—Gentlemen, this is a free discussion and the day of secrecy in the malleable industry has gone. These questions are very pertinent and interesting. I understand that some experiments have been made along that line, but just how far they have gone I do not know. I have heard that experiments have been made in melting the iron both with the cupola and the air furnace before refining it in the electric furnace. I do not know whether or not the men who are doing this have gone far enough to make it practical. I am sure this is a very interesting question and I hope some one is here today who knows something about this work.

MR. ENRIQUE TOUCEDA:—I do not believe many experiments have been conducted along this line. Pig iron can be

melted cheaply in the cupola and can be properly charged to produce white iron when directly cast into molds, but if instead of doing this it is transferred to an electric furnace at this stage for the double purpose of heating it for greater fluidity, and also to "dead melt" it, to get rid of occluded gases, great benefit might result at a comparatively slight cost, as arrangements could be made to keep the furnace hot between operations by oil burners. All must have noticed how abundant are the gases that come off of a ladle of air furnace iron, while metal for the electric furnace, as run, is absolutely quiet and free from occluded gases. If white iron castings could be made from iron as quiet as this and as free from gas, I have but little doubt but that a superior product would result, provided, of course, that other proper requirements were fulfilled.

THE CHAIRMAN:—I do not know that my information is reliable, but I have been told that somebody has been experimenting along these lines, taking advantage of the cheaper cupola melting cost. Of course, I do not know that it is a fact, but I have heard that it is.

MR. ENRIQUE TOUCEDA:—While not certain, I hardly think that at the present price of malleable iron, one could afford to melt and refine in the electric furnace; and, besides, I see no reason for refining in any event, as pig iron, with elements way within the limits for the production of good and superior malleable iron, can be purchased as cheaply as pig iron in which these elements are higher than will produce superior malleable iron. The thing that you must keep in mind is that steel always contains combined carbon and that the kind of steel that is made in an electric furnace always contains a large amount. The higher the combined carbon the more injurious the effect of phosphorus and of sulphur. The structure of malleable iron is practically all carbonless iron, the carbon that is present being in the free state, and for this reason an amount of impurity can be safely present in malleable iron a portion of which only would be fatal to superior steel. In other words, there is no incentive to refine in the case of malleable cast iron.

MR. W. P. PUTNAM:—Mr. Gilmore makes the statement in his paper that the "use of a high carbon pig such as charcoal, would carry more low carbon material in the shape of steel".

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It has been my experience that we can obtain just as high carbon in coke iron as in charcoal iron. We have not been able to carry any greater quantity with charcoal iron than with coke iron. I would like to ask Mr. Gilmore what the differences are.

MR. L. E. GILMORE:—I think charcoal iron has a higher percentage of carbon. Of course you can undoubtedly manipulate coke so as to produce a larger amount of carbon, but as to using more scrap with the charcoal pig than the other, you will have to take a larger amount of silicon, and if your silicon is less you would not carry any more scrap with your charcoal than you would with coke iron. I would not like to make any statement to the effect that the percentage of carbon is larger. We cannot consider just one element, carbon, but we must consider the silicon.

THE CHAIRMAN:—Is it your idea that with a fixed carbon content in both scrap and pig you can carry more silicon?

MR. L. E. GILMORE:—As a matter of fact, there is no advantage in using charcoal pig for the sake of carrying a little more scrap.

MR. C. L. BERGER:—In regard to the length of time of melting, I would like to ask if Mr. Gilmore has conducted any experiments and if he has any definite data.

MR. L. E. GILMORE:—I cannot give any data on experiments along this line. We have made some experiments with sandless pig and we have found the sandless pig melts more rapidly than the sand-cast. You will notice that the pig always melts from the end to the sand part and that the sand part will remain unmelted, so the larger surface you expose to the direct heat of the fire, the greater the melting.

THE CHAIRMAN:—I think a very simple way of settling that question is to take a ladle of iron and dip a sprue into it. You will find the end of the sprue that is free from sand will melt quickly, while the part covered by sand will resist the melting action much longer. That ought to be a simple way of demonstrating that fact. I suppose it is the same way in the furnace; the pig will begin to melt quickly on the ends free from sand, in fact much quicker than on the sand-covered portion.

MR. W. J. BENNETT:—I am not in a position to quote the name of the malleable concern which has made a percentage test of time saving, but a large malleable iron corporation has made continued monthly tests based upon monthly heats of the time of melting sandless pig as against sand pig, and it has found 20 per cent time saved in the melting of the sandless pig.

THE CHAIRMAN:—That is of some interest. Most of us are interested in the saving of fuel. Can you tell us anything about the saving of fuel, Mr. Bennett?

MR. W. J. BENNETT:—I could not make a positive statement about that.

Standardization of Air Furnace Practice

By A. L. Pollard, Batavia, N. Y.

The air furnace of today has been developed by many years of patient endeavor on the part of malleable founders. It has now reached a stage where improvement either must be very slow and must show year by year diminishing returns in added efficiency, or new methods and materials must be discovered. The scientific study and standardization of what has been already developed, for the most part empirically, will be the guide to the improvements of the future.

The air furnace has survived and has been developed to its present form by reason of its fitness under conditions as they actually are, which, by the way, is the highest reason for the survival of anything. Its inefficiencies may be deplored, but a great deal is asked from it. It must melt quickly, must not be too high in first cost and must be adaptable to a fairly wide range of capacity.

With the data now available, there is no reason why a furnace cannot be constructed which will work exactly the same every day under the same general conditions. The design is the first consideration. One dimension is limited, namely, the width. The furnace must be narrow enough to permit easy skimming as well as to allow the construction of easily supported bungs. This width is approximately 7 feet inside. The design is then confined to six main points, as follows:

1—Length of hearth.
2—Depth of bath.
3—Length of firebox.
4—Height of roof.
5—Opening at neck.
6—Wall thicknesses.

Taking these in order, we will discuss factors Nos. 1 and 2. The length of hearth and depth of bath are mutually depen-

dent. To design a furnace of any particular capacity, we may start with an average bath of 6 inches, which will give us quick melting, or of some other depth, such as 10 inches, which will give us slower melting and somewhat colder iron. For average practice the writer recommends a depth of 8 inches. With the tonnage, width and depth given, it is a matter of arithmetic to determine the length of hearth. The hearth should be deepest just in front of the bridge wall where the heat is most intense, and shallow at the neck where melting is much slower. The tap hole, of course, is located at the deepest point of the hearth.

Grate Area

Third.—The grate area is a factor of much importance and is entirely a matter of experience. This area can be determined in two ways. It has been found that the ratio of grate area to hearth area should be about 1 to 4. Also, since the melting ratio is 1 to 3 or better under forced draft, and since we should burn about 50 pounds of coal per square foot per hour, we can calculate the area in this way. If we should consider natural draft, we would assume only 30 pounds of coal per square foot per hour and a fuel ratio of 1 to 2½. With forced draft we would obtain a melting speed for a 10-ton furnace of about 4½ hours. Natural draft would be much slower.

Fourth.—The roof must be high enough to allow free passage of the flame when the furnace is charged with cold stock. In a 10-ton furnace this will be about 3 feet 6 inches at the deepest point. The roof should be no higher than necessary, as the most effective heating factor is in radiation from it. Also, it has been shown that gases are most effective in heating when moving at a high velocity. Obviously, the lower the roof, the greater this will be. The roof should be as nearly flat as possible, sloping gently down at the back. There is absolutely no advantage in the wierdly curved and indented roofs which some old furnaces have.

Fifth.—The opening at the neck is a point of great importance. It must be just right for successful operation.

It is entirely dependent upon the volume of gases passing through the furnace and upon the draft. This opening, in a 10-ton furnace should be about 3 square feet in area, but it should be adjusted as conditions of draft vary to always give a slight back pressure in the furnace. In other words, the total pressure of gases at this point should slightly overbalance the suction from the stack. Of course, in a natural draft furnace, this relation cannot be maintained, and consequently little or no air can be admitted over the bridge wall. The necessity for this back pressure is due to the fact that unless there is an appreciable pressure, a large amount of air is sucked in through the doors and roof, which tends to cool the furnace and greatly lower its efficiency.

Sixth.—The furnace walls may be either 9 or 13 inches in thickness. Thirteen inches is best and most economical. Less heat is conducted through them and at the slag line the inner 4 inches can be removed and replaced without disturbing the entire wall.

Disadvantages in Air Furnace Construction

The possibilities for improvement in air furnace construction open an interesting subject for speculation. The disadvantages of the furnace may be briefly summarized as follows:

1—Exhausting labor of firing and skimming.
2—Large amount of heat lost in waste gases.
3—Large amount of heat lost through bungs.

Considering these points in order, we have,

First.—The labor of firing has long been a difficult point in air furnace practice. It is difficult to get and keep good firemen. There are only three ways out of this difficulty, considering coal as fuel. One is, the utilization of the open-hearth furnace with regeneration, which we are not considering here. Another is in the use of automatic stokers. Some furnaces are equipped with these, which are giving satisfaction, but there is opportunity for much improvement. The writer believes that by far the most economical and best method of firing air furnaces is in the use of automatic stokers. A third method is by the use of pulverized fuel. This seems

to offer possibilities, but it necessitates a large investment in equipment.

Second.—Concerning the heat lost in waste gases, unless we consider the open-hearth, there is absolutely no opportunity for improvement in the furnace itself. To attain a melting temperature in the furnace requires that the waste gases leave the furnace at that temperature. The waste heat boiler offers a good method of utilizing this lost heat, but this is outside our present discussion.

Third.—The heat lost through bungs also is difficult to overcome. Under present practice, where removable bungs are in use, the thickness cannot be much increased, as it is necessary to keep all parts of the brick, through which the resultant pressure line passes, below the softening temperature of the brick used. The only improvement that the writer can suggest is to make the roof permanent and suspend it from one or more points between the skewbacks. This, of course, would necessitate charging from side doors.

Furnace Operation

Furnace operation starts with the mixture of pig iron, sprue, scrap, etc. This, so long a matter of mystery, is perhaps the simplest part of furnace operation; however, for best results it must be done along scientific lines. Having the analysis of the various materials, knowing what we desire to do, and with data from a few heats showing what elements are oxidized and to what extent, it is then a simple matter to make the mixture. The decision as to the final analysis of the heat is very important. It will depend largely upon the class of work. The writer's opinion is that the proper analysis should be about 2.50 per cent carbon and as much silicon as the heaviest section will carry without precipitating graphite.

The really difficult part of air furnace operation is in burning the proper amount of coal and adjusting the draft. Improper draft is the most frequent cause of failure. This subject is simple in theory, but seems to be difficult in practice. Starting with a properly designed furnace and a certain charge, we can find the amount of coal which should be

burned. This amount of coal should then be shoveled in, at frequent intervals. Air enough should be admitted under the grate to burn all the coal with a somewhat smoky flame and air enough should be admitted over the bridge wall to burn the fire box gases with a clear flame. Next, the opening at the neck should be adjusted to give a slight back pressure. The back pressure is right when the flame just tends to shoot out from the furnace openings.

Standardized on Basis of High Quality

If the malleable business is to be standardized on a basis of high quality we must know exactly what we desire to do and then do it in a thoroughly scientific manner. It is quite possible to have every heat poured of the right analysis and at the right temperature and this should be our constant aim. The question of proper annealing is so difficult that we cannot afford to complicate it by improper furnace operation.

Discussion

MR. A. B. ROOT, JR.:—I am not engaged in malleable foundry work, but I came here this morning thinking I might get some information. What is the gain in time of melting in a malleable air furnace, and have experiments been made with insulated linings in air furnaces? I would like to know also if malleable melting practice necessitates the use of mechanical draft. I would appreciate knowing the saving of fuel and time of melting, if any, and if there is a saving with the forced draft over the natural draft air furnace.

THE CHAIRMAN, J. P. PERO:—Is anybody prepared to answer these questions? Mr. Gilmore, you are familiar with natural draft practice, have you any recollection of the time and also of the coal consumption of say a ten or twelve-ton heat?

MR. L. E. GILMORE:—Without draft an air furnace will be much more economical in melting than one having draft. With

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natural draft from 15 to 20 tons can be tapped out in eight hours and the same heat, with forced draft, I think could be tapped out in from four to six hours. As for the saving in coal consumption, with the natural draft it perhaps will be 1 to 2½ and some might do better than that. With forced draft, anywhere from 1 to 2, or 1 to 3 might be done, but you will burn coal in forcing the draft.

THE CHAIRMAN:—Has anyone anything else to offer along this line? I believe it is considered we have more control over the forced draft than over the natural draft, and I think more malleable men find they can get better results out of the forced draft.

MR. A. B. ROOT, JR.:—I would like to inquire whether any experiments have been made with insulated brick?

THE CHAIRMAN:—Has anybody anything to say about that? Personally, I know of none.

MR. ENRIQUE TOUCEDA:—In connection with the question of insulating the walls of an air furnace, one reason why these furnace walls are not insulated is the fear that by lowering the loss of heat, due to radiation, the brick at the slag line will deteriorate more rapidly than it does at present; but I believe that such walls should be insulated and the manner to do it is to taper the insulation from the hottest zone in the hearth, which lies just in front of the fore bridge wall, to the rear bridge wall. In this manner, loss due to radiation, will be uniformly lessened as the temperature in the hearth falls from bridge to bridge, and a more constant temperature will be maintained in the entire hearth at all points.

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Coal—Its Origin and Use in the Air Furnace

By F. Van O'Linda, Chicago

The coal trade of the United States has enjoyed a constant growth in proportion to the expansion of business, the output of the bituminous grade in 1914 having aggregated 435,000,000 tons. The industries depend on it for power, the majority of people rely on it for heat, and yet the average man knows little of its widely different characteristics and cares less. However, I will venture to state that in no way can knowledge be made to pay dividends more quickly or surely than in a study of the combustion of coal. That this problem is of prime importance to the manufacturer is indicated by the large number of devices that have been invented for the purpose of economizing fuel consumption.

In the long-ago period of coal-making, our continent was covered with great marshes in which grew immense tree ferns with large woody stalks and spear-shaped leaves. These ferns grew rapidly and to tremendous size, but subsequently decayed and fell into the swamps. The earth's surface then was submerged for a period, and this was followed by great movements of the earth's crust due to its cooling off which in turn covered the coal with shale and rock, and great pressure was exerted upon it. Hidden away from oxidizing effects, this coal piled up in Nature's great storehouse to be drawn upon today. How many times our old world was submerged only to appear again, what great convulsions of Nature took place and how long ago it happened can only be guessed at, but this is certain—it is not a new world, and the coal which we burn with so little thought today is worthy of our interest if only from the standpoint of its antiquity. It must be apparent that in such

a process many different grades of coal were formed, having varying degrees of purity and ratios of fixed to volatile matter, and we are beginning to understand that these different coals require proper handling if the best possible results are to be obtained.

Coal is merely a package in which a certain amount of heat is delivered to us, but if we are to get the full measure of heat from it, we must understand something about what it contains.

Combustion

Combustion is the phenomenon exhibited when substances unite chemically with one another, and every chemical change is accompanied by an energy change. For example, hydrogen and oxygen are odorless, colorless and tasteless gases, and so long as they are kept separate they are subject to the laws of gases, but if they are brought together under certain established laws, a chemical change takes place, hence an energy change. These gases have united to form a new compound, water, having none of the characteristics of a gas, but water can be seen and tasted. This applies also to the combustion of coal. The chemical change is brought about for the sake of the energy change; the coal disappears, the carbon and hydrogen in the coal unite with the oxygen in the air with such rapidity that they develop a high temperature and new compounds are formed.

Coal in the Malleable Industry

The malleable iron manufacturer has an interest in coal which is threefold: First, it melts his pig iron, sprues and scrap in the air furnace and brings it to a condition for casting; second, it anneals the hard iron casting, and third, it furnishes power for numberless operations in his foundry.

However, the use of coal for melting only will be discussed. Coal for air furnace use must be low in sulphur and phosphorus, high in volatile matter, combustible and should carry a long, hot flame. When firing, it is preferable to throw the coal directly onto the fire instead of coking it in front of the door.

and since during the first three or four minutes the coal is giving off its heavy gases, plenty of air should be admitted at this time. If possible, the bottom wind should be partly cut off after these heavy hydro-carbons are driven off, because otherwise the excess air will pass through the furnace and out of the stack taking heat with it. No advantage is to be obtained from coking the coal before spreading it on the fire, thereby making two operations of one. Coal should be spread from the shovel when firing, but if coke is desired, why not fire coke in the first place? Air furnace melting requires flame, and coke is a short flame fuel. I cannot agree with those who claim that radiation plays an all-important role in the air furnace. It has its part in the melting operation, but flame is absolutely necessary, or otherwise the low volatile smokeless coals from Maryland and West Virginia which give off great heat, but little flame, could be used. Some furnaces will melt satisfactorily, but are slow in heating the iron, and in almost every case this is due to a short flame or the flame passes high in the furnace and does not sweep down upon the bath.

Suggestion for Firing

Too much coal should not be fired at one time; three or four shovelfuls spread on the fire every three minutes give good results as the practical banking of a fire by covering up all the incandescent coal gives a heavy, smoky flame, with low available heat value in this practice. For the complete combustion of each pound of coal, 15 pounds of air are required, and with small, frequent firing, the coal and air supply are more nearly equal. The placing of the top wind is important. If the pipes point directly down into the furnace, the air forms a screen through which the flame has to break. The pipes should be so placed that the blast follows the course of the flame and becomes a part of it. When the flame is held low in the furnace it will cut through the pig and sprue during melting instead of hurdling over it. The heat also will be shortened for the flame will hug the iron, causing it to heat quickly and at the same time it will cover the bath and prevent oxidation.

The phosphorus and sulphur content of the coal should be low. While sulphur has considerable heat, it is an element to be avoided in air furnace practice. Ash is the non-combustible residue left when the fuel is burned. Some coals show less than 3 per cent, while others may contain as high as 15 per cent of non-combustible matter. Professor Somermeier, of the Ohio University, in referring to coal ash, says: "The negative value of ash in coal, due to extra expense in handling and greater trouble to operate the fire together with possible lower efficiency should be taken into consideration."

The United States government counts this negative value at 2 cents per ton for each per cent of ash above the standard ash established for a particular specification. Let us see how this would work out for a foundry buying its coal not on cost, but on efficiency. "A" bids $1.30 per ton at the mines for coal having a heating value of 14,648 B. T. U.'s with ash at 3 per cent. "B" bids $1.20 for coal having 14,000 B. T. U.'s with ash at 6 per cent. "C" bids $1.10 for coal having 13,700 B. T. U's with ash at 9 per cent. Taking the lower ash, 3 per cent, as the standard, the 3 per cent excess in ash of "B" is equivalent to 2 cents per ton on the bid price, so "B" is raised to $1.26, and "C" with 6 per cent difference is raised to $1.22. The cost per million B. T. U.'s on the above coals, therefore, would be as follows:

$$\text{"A"}\ \frac{\$1.30 \times 1000000}{14648 \times 2000} = \$0.0443$$

$$\text{"B"}\ \frac{\$1.26 \times 1000000}{14000 \times 2000} = \$0.045$$

$$\text{"C"}\ \frac{\$1.22 \times 1000000}{13700 \times 2000} = \$0.0445$$

Although as originally bid "A" was 10 cents per ton higher than "B", and 20 cents per ton higher than "C", it is thus shown that "A", the supposed highest bidder, was in reality the lowest bidder when true values are considered, and if each per cent

of ash is a difference of 2 cents per ton in Pennsylvania, what would it be on the same coal shipped to Chicago or beyond? And it is in consideration and pursuance of these true values that will bring better results in the burning of coal in the air furnace.

Report of the Committee on Standard Specifications for Malleable Iron Castings

During the past year the members of your committee on Standard Specifications for Malleable Iron Castings held several meetings with a similar committee of the American Society for Testing Materials, with the result that a revised standard was prepared and was adopted by the Testing Society at its last meeting. These revised specifications, which form a part of this report, now are presented for your consideration and approval. It is probable that another change in these specifications will be made which will involve specific standards for malleable castings intended for definite classes of work.

ENRIQUE TOUCEDA, CHAIRMAN,
Albany, N. Y.

Standard Specifications for Malleable Iron Castings

I. MANUFACTURE

Process

1.—The castings shall be made from iron melted in either an air furnace, open-hearth furnace or electric furnace.

II. PHYSICAL PROPERTIES AND TESTS

Tension Tests

2.—Tension test specimens specified in Section 5 shall conform to the following minimum requirements as to tensile properties:

Tensile strength, pounds per square inch	38,000
Elongation in 2 inches, per cent	5

Transverse Tests

3.—Transverse test specimens specified in Section 5, tested with the cope side up on supports 12 inches apart, pressure being applied at the center, shall conform to the following requirements as to transverse properties:

Thickness of Specimen, inches	Minimum load applied at center, pounds	Minimum deflection at center, inches
½	900	1.25
⅝	1 400	1.00
¾	2 000	0.75

Special Tests

4.—In addition to the tension and transverse tests, the inspector representing the purchaser may satisfy himself of the suitability of the iron used for the castings by breaking a reasonable number of castings before annealing to examine for excessive mottling or graphite spots. In the case of castings of special design or importance, he may also require test lugs of a size proportional to the thickness of the casting, but not exceeding ⅝ by ¾-inch in section. At least one of these lugs shall be left on the casting for final inspection.

Test Specimens

5.—(*a*) Tension test specimens shall be of the form and dimensions shown in Fig. 1. Transverse test specimens shall be 14 inches in length by 1 inch in width and either ½, ⅝ or ¾-inch in thickness. The thickness of the specimen selected shall be in proportion to the thickness of the casting which it represents.

FIG. 1—TEST BAR FOR TENSION TESTS

(*b*) Two tension and two transverse test specimens shall be cast in each mold with risers of sufficient height at each end to secure sound bars. All specimens shall be cast without chills, and with ends perfectly free in the mold.

(*c*) Four molds shall be poured to represent each melt. When the entire melt is used for castings which are subject to these specifications, two molds shall be poured within five minutes after tapping into the first ladle, and two molds from the last iron of the melt. When only part of the melt is required for such castings, two molds shall be poured from the first ladle of iron used and two molds after the required iron has been tapped.

(*d*) The molds shall be suitably stamped to identify the specimens.

The test specimens from one mold from the first and one mold from the last of the melt shall be annealed in the hottest part of the annealing oven, and the remaining specimens shall be annealed in the coldest part.

Number of Tests

6.—One tension and one transverse test specimen from each of the four molds representing a melt shall be selected for test. The remaining specimens shall be reserved, and shall be tested in case of failure to conform to the requirements specified.

Requirements

7.—If more than one tension or transverse test specimen from each of the two molds annealed in the two points in the oven specified in Section 5 (*d*) fails to meet the requirements as to tensile or transverse properties specified in Sections 2 and 3, the castings from that melt will be rejected.

III.—Workmanship and Finish

Workmanship

8.—The castings shall substantially conform to the sizes and shapes of the patterns, and shall be made in a workmanlike manner. A variation of 3/32-inch per foot will be permitted.

Finish

9.—The castings shall be free from blemishes, scale and shrinkage cracks.

IV—Inspection

Inspection

10.—The inspector representing the purchaser shall have free entry at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the castings ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the castings are being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

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Discussion—Standard Specifications for Malleable Castings

THE CHAIRMAN, J. P. PERO:—This is a report that should be fully discussed. The specifications as read have been adopted by the American Society for Testing Materials. They have not been approved by the American Foundrymen's Association and are presented for revision. We have got to raise the standards to a higher point. If there is any one factor that has militated against the use of malleable iron it is because our specifications have not been as rigid as they should be. I want to tell you right here, gentlemen, you have lost a lot of business in past years through that laxity, and if you want to get it back you have got to get your standard back to a reasonably high point and stay there. I feel that way, and we all have good reason to feel that way, and the malleable man who has been in the business any length of time and has given the matter any thought at all, must agree with me. We have a metal mighty good in itself—when properly made—and we have stood back and allowed our product to deteriorate, and in many instances a metal not as good as our metal has come in and superseded it. Gentlemen, you have got to make up your minds to work in order to get it back, but you can get it back if you will work conscientiously and keep the standard up when you get it back.

MR. ARTHUR W. WALKER:—I am very glad to hear the chairman of this meeting voice this sentiment. I am a member of this committee of specifications, although I was, unfortunately, unable to attend the meeting when these specifications were adopted, but it brings up the question of the advisability of the American Foundrymen's Association writing specifications on metals all along the line. I am sorry that the committee saw fit to make a reduction in the tensile strength to 38,000 pounds per square inch, in preference to raising it. It had under discussion also the advisability of raising the per cent

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of sulphur. I feel that the tensile strength should be from 38,000 to 40,000 pounds. It is so slight a difference and yet it is a step backward, as far as I can see.

MR. ENRIQUE TOUCEDA:—The specification was prepared for the purpose of covering general malleable iron only. There are a large number of manufacturers in the country, who make castings where a high ultimate strength is not required, but which has to be quite ductile. These gentlemen were represented on the committee and in deference to them and their conditions it was thought best, by all present, to lower the ultimate strength, but to raise the percentage of elongation. There are a large number of manufacturers who make malleable iron with both a very high ultimate strength and a high elongation, but as there is such a wide field for the other material and as this specification was for general malleable iron, we placed the figures as given. Personally I would like to see the ultimate up to 50,000 pounds.

THE CHAIRMAN:—While the specifications call for 38,000 pounds tensile strength, I am of the same opinion as Prof. Touceda and the other gentleman. There are too many manufacturers in our line who are just satisfied to get by. There are many of us here who represent the manufacture of railroad malleables, and it seems to me it would be wise to have a separate classification for this work. It would be good for the people who buy our products and I believe we ought to get our tensile strength higher. I do not believe there is a man here making iron as low as 38,000 pounds. I do not believe we, who are making railroad iron, should have the tensile strength less than 45,000 pounds.

MR. HUTTON:—In railroad, agricultural and chain work, why not get it under a classification covering everything instead of just one line?

MR. GEORGE C. DAVIS:—I think it is only fair to the committee working on these specifications to have that question fully considered, and the specification as adopted by the American Society for Testing Materials sent out to our entire membership accompanied by a note saying these specifications were intended for general use of the manufacturers of malleable castings, but with the understanding that other specifications

for their work would be adopted, and that these specifications would limit the specification for railroad work. As in all specifications, it is necessarily a matter of compromise, but that does not mean they can be faulty on that account. The old specifications, as I recall, provided for a tensile strength of 40,000 pounds. The elongation is double. To compensate there is a reduction of only 5 per cent in the tensile strength and I think that 38,000 pounds tensile strength would be quite ample, since railroad work requiring the higher tensile strength is perhaps irrevocably taken away from the malleable trade. At the several meetings of the committee, the Master Car Builders' Association was represented. At one of the meetings the B. & O. had one representative and at the other meeting the Pennsylvania railroad was represented. Their clamor was for something which was thoroughly ductile, and just simply on that point this was adopted for general work with the understanding that it was satisfactory to the railroads. The Master Car Builders' Association did not adopt it upon the spot, but such action is likely to be taken and the specifications already represent from 80 to 85 per cent of the malleable iron used, that is, agricultural and railroad work. The chain work would want extreme tensile strength and no elongation.

MR. STANLEY C. FLAGG, 3RD:—It seems to me that if we are to go into this matter of specifications, we ought to leave that to the different works. A specification for railroad work might be uncertain for agricultural implements, and if we do arrive at a different specification, we can do one thing, and that is to stick to whatever specification we adopt. About a year ago the Pennsylvania railroad wanted some malleable iron for its electrification work from Philadelphia to Paoli. No specifications were submitted, but the railroad company demanded that 1-inch diameter test bars, representing the material, be bent at right angle without showing a crack. I heard they did succeed in getting somebody to make the malleable castings and that the people who made them got into a lot of trouble. I think this Association should stick to whatever standards it adopts. We cannot let a buyer force us into making any others, and this cannot be so if we all get together and adhere to a standard.

THE CHAIRMAN:—Personally I do not think that we want to keep changing our specifications every year. For a time at least, as the specifications stand, they should have our approval. I believe with the amount of research work that is being done and the interest the men of the malleable business are taking in better material, that perhaps a year or two hence we will be in a better position to adopt a standard that will do for all time. I believe it would be wise for us, who are assembled here today, to approve the specifications as far as they have gone. I think, as a matter of courtesy, at least, we should ratify the work of the committee.

MR. W. P. PUTNAM:—I make a motion that the specifications be approved as submitted by the committee.

MR. ARTHUR W. WALKER:—I wish to amend that motion in approving these specifications, by stating that we also recommend the study and preparation of specifications applying to various grades of work.

The amendment to the motion was seconded and carried and the specifications were approved and adopted.

Report of Committee on Specifications for Foundry Scrap

During the past year the Committee on Specifications for Foundry Scrap corresponded with various producers of scrap and also with dealers and consumers for the purpose of drawing up specifications covering the different classes of old material that would be agreeable to all concerned. Several sample specifications were obtained and studied. In order to stimulate interest in a further consideration of this subject, the following tentative specifications for steel, gray iron and malleable foundry scrap have been compiled:

Tentative Specifications for Steel Scrap

No. 1 Heavy.—Must be steel scrap of charging box size, that is, not over 5 feet long and under 18 inches wide with no piece weighing less than 10 pounds. Bundled scrap is excluded.

No. 2 Heavy.—All pieces over 5 feet long and 18 inches wide not to exceed 600 pounds in weight and exclusive of frog, guard, switch and crossing rails, (unless cut apart) as well as structural material and girder rails and also exclusive of bent, curved or twisted rails.

No. 3 Heavy.—Frog, guard, switch and crossing rails not cut apart; structural material, and girder rails over 5 feet long and 18 inches wide.

No. 1 Light.—Material of charging box size, that is, not over 5 feet long and under 18 inches wide, under 10 pounds, in weight, but exclusive of bundled scrap, turnings, drillings and borings.

No. 2 Light.—Turnings, drillings and borings, free from other metals, dirt and lumps.

No. 3 Light.—Bundled and all steel scrap not otherwise specified. Must be of charging box size, that is, not over 5 feet long and under 18 inches wide.

Tentative Specifications for Cast Iron Scrap

No. 1 Machinery.—All miscellaneous machinery broken to cupola size; no piece to weigh more than 100 pounds.

No. 2 Machinery.—All pieces weighing over 100 pounds, such as heavy bed plates, large gear wheels, etc. This material to be broken by the purchaser and used in the cupola or charged in an air furnace.

No. 1 *R. R. Scrap.*—All cast iron of cupola size coming from standard railroad cars and locomotives, except brake shoes.

No. 2 *R. R. Scrap.*—All cast iron coming from coal companies including pit wheels.

No. 1 *Brake Shoes.*—All shoes without inserts.

No. 2 *Brake Shoes.*—Shoes with inserts other than cast iron.

Stove Plate Scrap.—All stove plate, radiator castings, light plumbing castings, etc.

No. 1 *Grate Bars.*—All grate bars free from burnt material.

Tentative Specifications for Malleable Iron Scrap

No. 1 *Malleable.*—All malleable parts coming from locomotives or standard railroad cars and from street railways.

No. 2 *Malleable.*—Light scrap coming from agricultural machinery and light fittings.

S. D. SLEETH, Chairman.

Westinghouse Air Brake Co., Wilmerding, Pa.

Discussion—Standard Specifications for Foundry Scrap

THE CHAIRMAN, MR. R. A. BULL: — Are there any remarks on Mr. Sleeth's report? It might be pertinent to ascertain the sense of the meeting concerning the continuance of this committee.

MR. H. COLE ESTEP: — The scrap problem is a serious one. It is practically the only unknown element that goes into our mixtures at the present time. We know what elements our pig iron and fuel contain, also we know pretty definitely the composition of the returned scrap, but we know very little about the scrap we buy. There are specifications on which scrap is sold that it might be worth while to study. I refer particularly to railroad specifications. A great deal of the scrap used in the country comes from the railroads, and the larger systems have developed more or less elaborate specifications according to which this scrap is sold. A great many of the consumers accept these specifications, and I, therefore, move that at the discretion of the Executive Committee, this subject be continued for another year.

DR. RICHARD MOLDENKE: — I would like to second that motion. I think that it is a very important matter for the committee to keep right on working, and I would like to see the committee add also the subject of investigating stove plate scrap. I get around the country a great deal professionally and one of the things I do is to look at the scrap piles. There usually is some stove plate, and I can pick out many burnt grate bars. Here is the secret of a lot of foundry trouble. If foundrymen knew that the burnt grate bars are the cause of much of this trouble, they might specify that their stove plate scrap should not contain any burnt grate bars, whatever.

The motion was adopted.

The Relation of the Foundry Foreman to His Employer

By S. V. Blair, Former President of the Associated Foundry Foremen.

The 1915 convention of the American Foundrymen's Association will be of particular interest to the foundry foreman, marking as it does, the amalgamation of his organization with the more powerful parent body. This consolidation was effected by the officers of both societies at the last annual meeting at Chicago, the formal transfer having been made this year under terms very favorable to the foremen's association. It is hoped that this will result in the renewed interest of foundry foremen in the educational movement, the prime object of the former association, and the foundation stone of the one of which we now form a part.

The generous terms under which the membership of the Associated Foundry Foremen acquired and can maintain their standing in the parent organization is a gratifying evidence of the good will of the latter, an acknowledgement that the foreman of the foundry is a factor to be more considered in the future, and is the final step in practical co-operation, the benefits of which will accrue in proportion to the number of foremen who avail themselves of the opportunity thus presented.

The era of rule-of-thumb and mixing by fracture has passed, and with it passes the foundry foreman who has not taken advantage of his opportunities for technical study. When the foreman is lacking in technical knowledge, the employer frequently assumes duties properly belonging to the man in charge of the foundry, thereby lowering the standard of foremanship and making that position of minor importance and less secure.

The employer, in this case, has availed himself of the opportunities now afforded by alliance with the American Foundry-

men's Association, to familiarize himself with modern foundry practice, but he still needs the co-operation of his foreman to insure best results.

The present consolidation of foundry interests will raise automatically the standard by which the qualifications of the foundry foreman is gaged, harmonizing the technical with the practical and the inefficient foreman will be left ouside the circle.

The fact that employers' associations have been organized is sufficient reason for the necessity of their existence. The history of the American Foundrymen's Association shows a continuous increase in membership and influence and since the most progressive foundrymen in the country are affiliated with it, it will continue to grow in strength. Therefore, the logical course for the foreman to pursue is the one which will enable him to remain in touch with the progressive element, not overlooking an opportunity to increase his efficiency by study outside of his working hours.

Frequently a good molder from the shop force is selected to fill the position of foundry foreman. Before assuming these responsibilities, he, of course, is suspected of having other qualifications, but not many employers credit him with more than the ordinary molder's knowledge of the science of mixing and melting iron. He is on the job only a short time when "these things are to him an open book". He has acquired comprehensive knowledge of the mysteries of producing castings suited to the various requirements of the trade.

That is, provided he can get by with the bluff.

In his haste and ambition to make good on the job, he has applied his ideas, gleaned from sources more or less reliable, but his mainstay is the cupola man, the real boss on the job, except where these matters are directed from the office, as in many well regulated shops.

However capable a man may become under this system of training foremen, experience has taught us that many of the problems that arise in everyday foundry practice are beyond the ability of the average man with only practical experience to guide him. Too many of us have been content to allow

an expert to be consulted rather than to apply ourselves to the technical study necessary to be prepared to meet the situation.

The present transfer of membership clearly outlines the duty of every foreman whose employer is alive to his own interests, and the natural result of this closer affiliation of what heretofore have been regarded two distinct interests should result in the realization of the aims of the original founders of the surviving association, opening the way to a better understanding between employer and foreman in the line of practical co-operation.

The future cannot fail but produce profitable results to both the management and the man in charge of the foundry, as both now are fraternally bound, with but one object in view, namely—efficiency at a minimum cost of production.

Resolution on the Death of Edgar H. Mumford

ADOPTED BY THE AMERICAN FOUNDRYMEN'S ASSOCIATION, AT ITS ANNUAL MEETING AT ATLANTIC CITY, N. J., SEPT. 28 TO OCT. 1, 1915

RESOLVED, That in the death of Edgar H. Mumford, the American Foundrymen's Association, as well as the foundry world, has lost a man of rare attainments. He was cultured, kind of heart, and ever ready to help the cause of industrial education.

An inventor of marked ability, endowed with unbounded enthusiasm in his chosen field, an ornament in the group of workers who are striving to conserve human energy while advancing civilization.

He was one of Nature's gentlemen, whose worth was appreciated by all who knew him, an example of righteousness in daily life and a shining star in the gallery of distinguished men affiliated with the foundry industry.

RICHARD MOLDENKE, *Chairman.*
THOMAS DEVLIN,
PAUL KREUTZPOINTNER,
Special Committee on Resolutions.

The History and Development of the Molding Machine with Sidelights on Latter-Day Practice

By J. J. Wilson, Detroit, and A. O. Backert, Cleveland.

Among the vocational arts, molding takes rank as one of the most arduous and enervating, since it involves shoveling and lifting hundreds of pounds of sand in a few hours, together with ramming, lifting-off and closing molds and at the end of the day, pouring the metal which frequently must be carried a considerable distance from the cupola. Shaking-out the castings and cutting-over and tempering the sand also constitute a part of the molder's routine in most shops. Added to this exceedingly tiring labor is the skill of ramming, drawing the patterns, finishing, setting the cores and pouring, which constitute a part of the molder's trade.

In view of the molder's multitudinous duties and the many operations involved in the production of castings, it is not surprising to note that more than a century ago devices were invented to relieve the molder, mechanically, of the most difficult operations he is compelled to perform. Aside from the ramming of the mold, the drawing of the pattern is probably the most difficult of his duties, since upon his skill in lifting the model from the sand is dependent his previous ramming labor. If this operation is not performed accurately, the mold either is ruined or so much finishing is entailed that a new mold, particularly in medium or light work, can be rammed in equal or less time than that consumed in patching. Therefore, as we turn back the pages of history and review the patent records, it occasions no surprise to find that the first mechanical molding device was designed to back the pattern out of the sand. The elimination of the large amount of hand labor involved in ramming was the next problem attacked and among the early patents are those covering the use of hydraulic cylin-

ders, rollers and other devices intended to pack the sand mechanically. This step also was taken for the purpose of eliminating the lack of uniformity in the sand density of various molds rammed by the same man, as it is only too well known that early in the day molds will be rammed harder than those made last, reflecting the loss of energy on the part of the molder. The ramming of sand by the jarring principle was written into the patent records more than 45 years ago, but owing to the difficulties involved in packing the sand, this principle was allowed to lie dormant for nearly 20 years, when compressed air was applied as the power for operating the machine to jar-ram the sand. In the meantime various schemes and processes were tried out to eliminate hand ramming. Among these was the use of a water bag intended to pack the sand by gravity, due to the weight of the water, which compressed the sand to its greatest density at a point farthest from the pattern instead of in the opposite manner. Compressed air also is utilized for this purpose and the vacuum principle was applied for drawing the pattern. It is needless to add that the latter had limited vogue, owing to the difficulties involved in creating a vacuum when the parting surfaces of the patterns became roughened. It was recognized generally that the jarring principle had merit and largely due to the indefatigable efforts of the late Charles Herman, of Pittsburgh, who persisted in its application in spite of many reverses, it is recognized today as one of the greatest labor-saving methods involved in mechanical molding.

Earliest Mechanical Molding Devices

Among the earliest mechanical molding devices the match-plate and the pattern plate must not be overlooked. The mounting of patterns on boards also relieved the molder of considerable skilled work and it is probable that some of these expedients even antedate the equipment to draw the pattern from the mold. Hinged pattern-plates, as well as match-plates, must be accorded a place among mechanical molding devices, owing to the facility with which they enable the molder to lift the pattern from the sand and to print-back, if necessary. In the stove trade particularly, where flat work predominates,

these hinged plates are used extensively today with marked success.

Concurrent with the jar-ramming machine development was the invention of equipment to draw the pattern from the mold and this led to the construction of the stripping plate machine, which supports the mold while the pattern is accurately lowered or stripped away. For the purpose of ramming the sand the hand squeezer type of machine was introduced, which accomplishes in one operation, what the molder performs with many, by the use of his rammer or in stepping-off the mold. Modifications of the stripping plate followed in rapid succession, some of which reverse the operation by dropping the mold away from the pattern in place of lowering the pattern away from the mold.

In America, as well as in Europe, the greatest advances in molding machine practice have been made in the last quarter of a century and this progress was greatest in the last 10 or 15 years. This period has witnessed the introduction of several distinct principles of ramming molds, including the packing of the sand by gravity, the sand being dropped from a predetermined height onto the pattern and into the flask. The projection of sand by air onto the pattern and into the flask also is a development of the not distant future, and this principle now is being successfully applied in making cores. The ramming of the sand by heavy rollers also is being successfully accomplished and great economies are effected, particularly on large, flat work.

Combinations of Molding Operations

Combinations of the mechanical sand ramming and pattern drawing operations soon followed the construction of machines performing a single operation only, as it was realized that by eliminating as much hand work as possible the output could be materially increased and unskilled labor could be employed. This led to the introduction of the hand squeezer with stripping plate attachment, squeezers of the adjustable drop plate type and similar machines that mechanically perform the ramming of the sand and the drawing of the pattern. The hand-rammed roll-over molding machine marked another distinct improvement

and this likewise is built today in many combinations, incorporating almost every operation involved in mold making with the exception of shoveling the sand, lifting-off and setting the cores. Similarly, the jar-ramming molding machine has been variously combined with other operations until today practically no skilled labor is required in the production of the most complicated machine-made castings. In the order of their development, molding machines may be classified as follows:

Squeezers, stripping-plate machines, roll-over machines, jar-ramming machines and machines of the various combination types.

These again may be subdivided approximately as follows:

SQUEEZERS

Hand squeezers.
Power squeezers.
Hand squeezer with stripping plate attachment.
Squeezer of the adjustable drop plate type.
Automatic machines.

STRIPPING PLATE MACHINES

Stripping plate machines, hand and power draw.
Stripping plate machines, drop plate type.

ROLL-OVER MACHINES

Hand-rammed roll-over.
Hand-rammed, power roll-over and power draw.
Hand-rammed, hand roll-over, foot draw.
Gravity machine, roll-over, pattern draw type.

JAR-RAMMING MACHINES

Plain jar-ramming, air and electrically operated.
Foot jolt machine with roll-over attachment.
Hand jolt machine with roll-over attachment.

COMBINATION MACHINES EMBODYING JAR-RAMMING PRINCIPLE

Jar-ram, roll-over, pattern-drawing.
Jar-ram and squeezer.
Jar-ram, squeeze and pattern-drawing.
Jar-ram, squeeze, roll-over, pattern-drawing.
Jar-ram, pattern-drawing.
Jar-ram, roll-over.
Jar-ram, air-squeeze, stripping plate.
Jar-ram, split pattern.
Jar-ram, squeeze, split pattern.
Jar-ramming and stripping plate.
Jar-ram, squeeze and stripping plate.

History of Molding Machines

No historical discussion of molding machine development would be complete without a reference to the magnificent paper entitled "Machine Molding", presented by Wilfred Lewis before

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the Franklin Institute, Philadelphia, May 18, 1911. Referring to the development of mechanical molding operations, he speaks as follows:

"In the year 1800 an English patent was granted for molding screws, the patterns for which were backed out of the sand by lead screws of the same pitch. This was simply a pattern-drawing machine of rather ingenious construction, but the English records do not touch again upon machine molding until 1839, when a very similar patent appears. From this time forward more interest seems to have been aroused and these patents were soon followed by others for packing sand by mechanical means, including hydraulic cylinders, stampers and rollers of the road-roller type. Machines for molding gears and pipes also appear in the first half of the nineteenth century and in 1843 we find an American patent on the molding of cannon balls. Later, in 1869, the first jarring machine patent was taken out, but it is not proposed to give a history of the art of machine molding from patent office records and it may simply be noted that the art began in a small way on bench work and continued chiefly in its application to small molds that one or two men could handle until the end of the last century. Larger work was not generally regarded as applicable to machine molding until the jarring machine began to emerge from a long period of obscurity and demonstrate its peculiar fitness for ramming large bodies of sand. Its development for large work belongs mainly to the present century and through its means the art of machine molding has been extended to embrace nearly everything molded in sand. But there are, of course, exceptions and peculiar difficulties which will always depend upon the molder's skill for their proper execution, with or without the aid of machine, and like any other equipment the installation of molding machines must depend upon the saving to be effected by their use and the outlay needed to effect that saving."

Some Inventors Too Enthusiastic

Not unlike the introduction of other new processes, molding machine development suffered considerably from the enthusiasm of the inventors of these devices, some of whom did not hesitate

to recommend their equipment for all classes of work absolutely regardless of its adaptability or whether the pattern could be mounted economically, or in a way that would produce the best results. In a measure, the use of molding machines for a time was retarded by the failures thus recorded, but today this feature largely has been eliminated from the industry, as most foundrymen are familiar with the types best adapted to their particular line of work. Also, the spirit of co-operation manifested by the manufacturers has proved helpful in reducing experiments to the minimum.

To the inventive genius of those who have specialized in the development of mechanical molding devices, the foundry industry is greatly indebted and reference here only will be made to those who have passed away and whose work is the greatest monument in commemoration of their efforts. This list includes Charles Herman, Harris Tabor, Henry E. Pridmore and the late E. H. Mumford. An army of inventors and manufacturers is active today in the further development of various types and in view of current advances, the art of mechanical molding still must be considered in its infancy.

In this country compressed air is most favored as the power for machine operations, although in Europe hydraulic power is extensively applied. Latterly, electricity has been adapted to molding machine operations and it is predicted that it will have more extensive application in the future.

The accompanying illustrations have been selected with a view of demonstrating the wide application of molding machines to various classes of work. No effort has been made to include all types, nor have all of the different lines of work been covered. However, since these are service views and represent actual and successful installations, they reflect, in a measure, the extent of the use of molding machines today in casting manufacture.

Use of Hinged Match-Plates

First, the method of making hinged match-plates for stove work will be discussed. Fig. 1 shows a match-plate molding department, the drag and cope halves of the mold being illustrated at *A* and *B*, respectively. The match-

plate frame is in position on the drag. An aluminum-zinc mixture is employed for making the plate, which consists of two parts aluminum and one part zinc; *E* is a view of the match-plate immediately after it was shaken-out of the sand, and *D* is the plate with sprues and risers removed. This plate contains the patterns of nine stove lifters. An adjustable frame from which match-plates of any size can be made is in position on the drag. The malleable iron hinges which are

FIG. 1—HOW HINGED ALUMINUM MATCH-PLATES ARE MADE

embedded in the aluminum are shown at *E*. When the mold is closed the frame is not removed, leaving a thickness between corresponding to the thickness of the match-plate.

Fig. 2 shows a wide variety of hinged aluminum match-plates for molding stove plate; *A* is a gas stove top, 26 x 28 inches, with a deadhead in the center containing four stove leg corners; *B* is a plate containing four gas stove burners; *C* has two heater door frames, on one plate, 21 x 30 inches; *D* is a gas stove heater door, 14 x 8 inches; *E* is a gas stove top, 25 x 26 inches, with two deadhead plates in the center; *F* contains

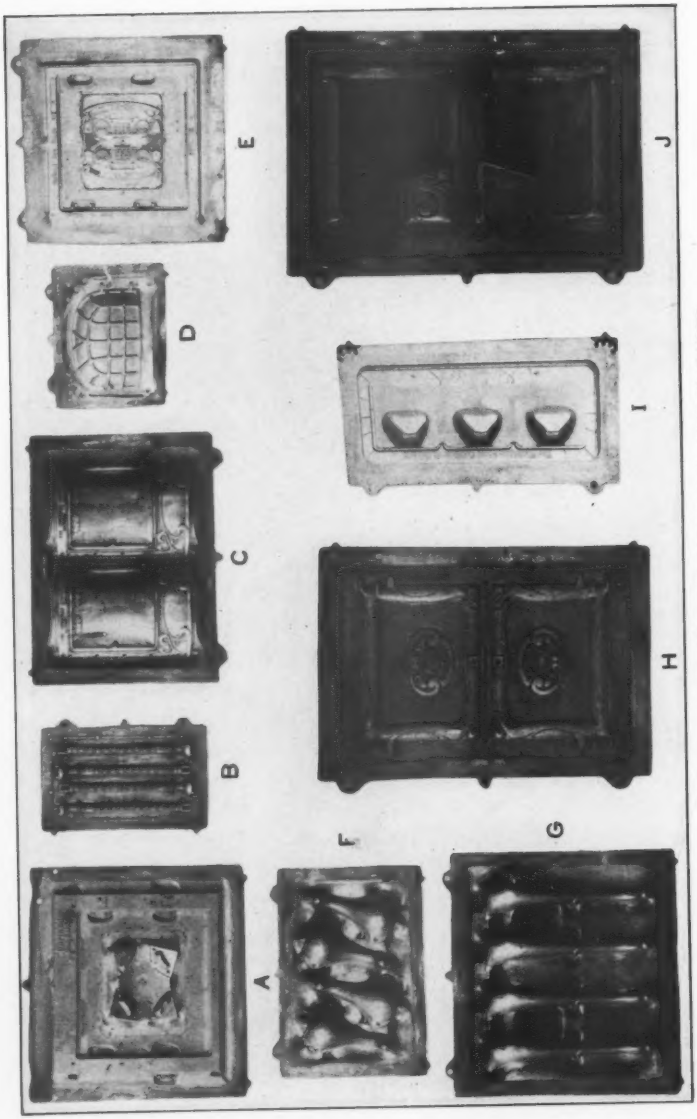

FIG. 2—HINGED MATCH-PLATES FOR STOVE PARTS

four stove legs on one plate, 13 x 27 inches; *G* shows four gas stove legs on one plate, 26 x 29 inches; *H* is a plate for two gas range oven doors, 21 x 30 inches, with deadheads in each; *I* is a three-burner gas stove hot plate, 16 x 35 inches, and *J* is a plate containing right and left sides of a wood cook stove, 23 x 35 inches.

Fig. 3 is a view of a floor mold, showing a hinged match-plate supported while the operator dusts facing on the drag

FIG. 3—HINGED MATCH-PLATE IN FLOOR MOLD

before printing-back. The application of this roll-up hinge process is an intermediate step in molding between simple hand operations and the molding machine.

Fig. 4 shows a large floor mold before closing, the match-plate having been lifted off. When these molds were made on the floor without the use of the match-plate, 23 was considered a good day's output, but 42 have been produced in one day by one man, and while 60 is the high mark, 32 is an average.

Fig. 5 shows another type of hinged flask. The mold is for a heater bottom casting. The pattern is in two parts,

FIG. 4—MATCH-PLATE REMOVED, MOLD READY TO CLOSE

FIG. 5—ANOTHER TYPE OF HINGED FLASK

the ash pan being in the cope half. The cope is rammed first, with the whole pattern in place. It then is rolled-over and the core is rammed. The drag is rammed last, the flask opened and the drag part of the pattern is drawn out of the sand. The mold is then clamped, rolled-over, opened and the ash pan pattern is withdrawn. The mold is then closed, clamped, and is ready to receive the metal. On the hinges

FIG. 6—HINGED FLASK AND MATCH-PLATE FOR MOLDING GRATE RESTS

in the foreground are shown the two tapering sprues which are ⅛-inch wide at their smallest end.

Fig. 6 illustrates the use of hinged flasks and match-plates for molding grate rests. The plate is made of cast iron, the drag side of the pattern being shown at the left and the cope at the right. The plates are grooved to fit the flask pins which insures rapid and accurate adjustment. When making the mold the drag is rammed first, rolled-over and the cope is then made. The flask is then opened, the pattern plate removed and the flask closed and clamped.

Fig. 7 illustrates a unique portable steel molding bench which straddles the sand heap. It will be noted that each bench is equipped with a knee pad vibrator.

Fig. 8 is a view of a floor of molds made on squeezers equipped with hinged match-plates. The utility of these hinged plates for stove work will be shown in succeeding illustrations.

Fig. 9 shows one of the squeezers on which stove plate

FIG. 7—PORTABLE STEEL MOLDING BENCH

molds are made by the use of hinged snap flasks and hinged match-plates.

Fig. 10 illustrates the method of raising and holding the match-plate in position while the operator dusts facing on the mold. In applying the hinged match-plate to squeezers a difficult problem had to be solved caused by the tilting of the drag when the cope is rolled up. This is due to the lack of support at the back end of the drag, as the bottom board used for squeezing is mold size, causing the flask to project its entire thickness on the four sides of the mold after it has been

FIG. 8—FLOOR OF MOLDS IN A STOVE FOUNDRY

FIG. 9—MOLDS MADE ON A SQUEEZER BY USE OF HINGED SNAP FLASK AND MATCH-PLATES

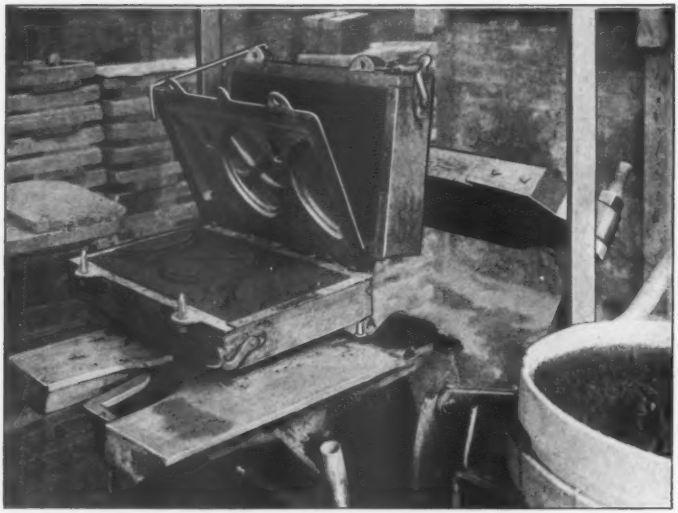

FIG. 10—PINS AT END OF DRAG FLASK PREVENT MOLD FROM TILTING

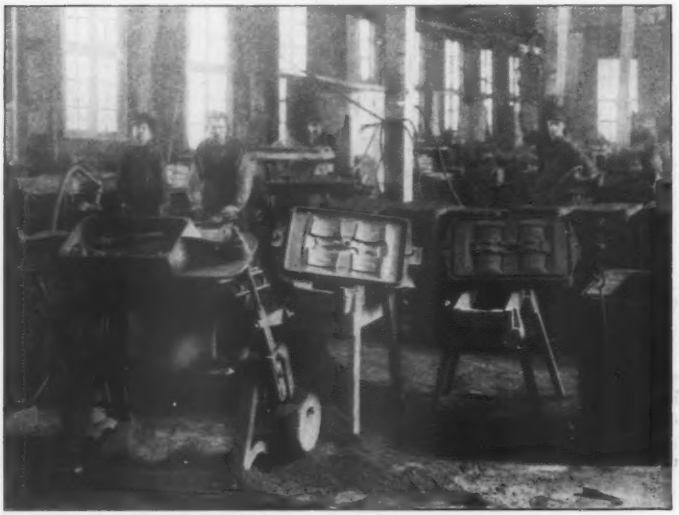

FIG. 11—AN EARLY TYPE OF AIR SQUEEZER

rammed. To overcome this difficulty two brass pins have been provided, one of which is shown at *A*, which can be raised or lowered by two wedges operating underneath the table, and guided by a handle. When the operator is filling the flask with sand, these pins are in their lowered position, which is accomplished by drawing out the handle referred to. After squeezing the mold, and before the cope is rolled back the pins

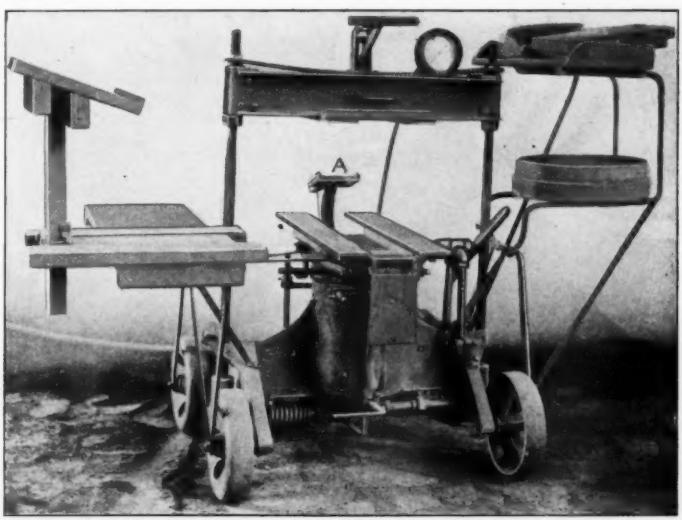

FIG. 12—COMBINATION SQUEEZER AND JAR-RAMMING MACHINE

are raised by pushing in the handle and they contact with the back end of the drag flask, supporting it while the cope is swung back, and until the match-plate is lifted out and the mold is closed.

Fig. 11 shows an early type of air squeezer equipped for molding firepot linings, four in a flask. The plates are arranged for multiple molding, the molds being stacked nine-high, making eight complete molds or 32 castings in one stack. Although designed practically eight years ago, it will

be noted that this machine, in some respects, is not unlike several of the later types of air squeezers.

Fig. 12 illustrates a combination squeezer and jar-ramming molding machine with the head thrown forward in squeezing position. It can be used also as a simple squeezer for comparatively heavy work. The piston which jar rams the mold also packs the sand by squeezing with its upward stroke when the head is in its forward position. When making a mold the

FIG. 13—ANOTHER TYPE OF SQUEEZER MOLDING MACHINE

flask, after being filled with sand, is jar-rammed on the table, the squeezing head in the meantime being tilted back. After ramming, the squeezer board is adjusted, the head is swung forward and the mold is squeezed. After lowering the piston the head is tilted back and the pattern vibrated. The cope is then lifted off and is set on the rest, *A*, while the pattern is being drawn from the mold.

Fig. 13 shows another type of molding machine for snap flask work on which both cope and drag halves are molded simultaneously. The drag and cope halves of a mold for a

number of gas stove burners with the cores in position, are illustrated. This machine is of the hand squeezer type and is well adapted for light work.

Fig. 14 illustrates a power squeezer equipped for molding gas range burners. The patterns are mounted on a match-plate, the drag being rammed and rolled over, after which the cope is made. On this machine 80 molds constitute a day's output.

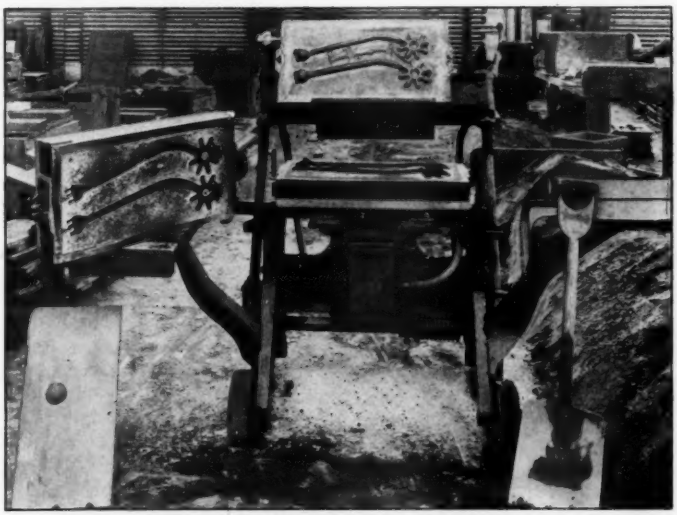

FIG. 14—POWER SQUEEZER FOR MOLDING GAS BURNERS

Stripping Plate Machines

The stripping plate principle has been applied to a wide variety of machines for both light and heavy work. These are used extensively in the manufacture of castings for agricultural implements, gas engines, heating boilers, grate bars, piano plates, etc. In automobile manufacture machines of this type are employed for many patterns, and Fig. 15 shows one equipped for making cylinder molds. They are generally used in pairs, one for making copes and the other for producing the drags. As rapidly as the molds are made they are placed

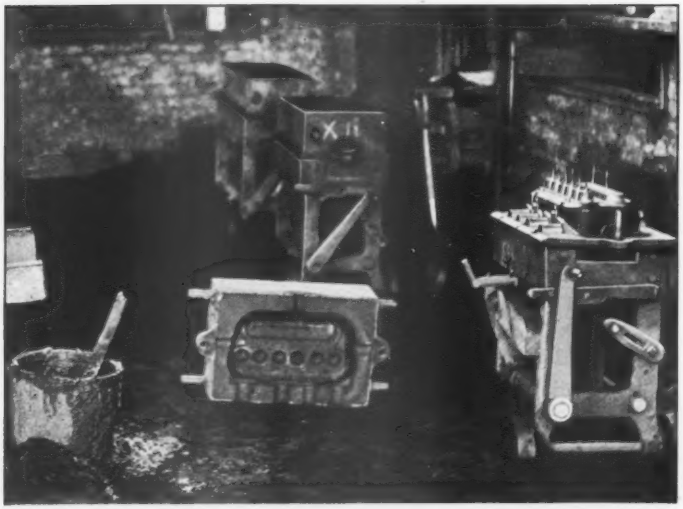

FIG. 15—STRIPPING PLATE CYLINDER MOLDING MACHINE

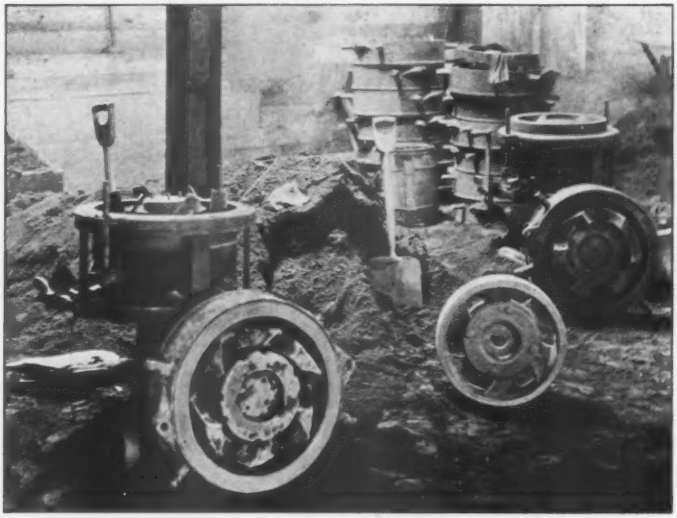

FIG. 16—PAIR OF STRIPPING PLATE MACHINES FOR MOLDING FLY WHEELS

on a stand shown at the left and are blacked by spraying. In this case, 20 cores are set in the mold, including four small prints in the bottom, a water jacket core divided into three parts, four combustion chamber cores, four valve cores, one intake core and four barrel cores.

Fig. 16 shows two stripping plate machines equipped for molding fly wheels. One is used for making copes and the other for molding the drags. One of the finished castings

FIG. 17—LARGE FLOOR OF PISTON MOLDS

is shown between the machines in this illustration. The castings weigh 102 pounds each and two men put up 60 molds per day.

The large amount of work that can be put up on stripping plate machines is well illustrated by the floor, Fig. 17, which represents 60 per cent of a day's work of piston molds. The average output of one man is 225 molds in nine hours and at the time when this photograph was made 138 molds had been put up. A single flask is used without a cope, the dry sand core being suspended from its own flange and held down by

iron weights. The faces of the flasks are machined so that the cores will be centered accurately. The casting weighs 7½ pounds and the molder has the assistance of a laborer in pouring-off. The machine is shown in the foreground.

Fig. 18 shows a view of a floor of single barrel cylinders molded on stripping plate machines. Special cast iron flask equipment has been designed to reduce to the minimum the quantity of sand for each mold. By the aid of this equipment

FIG. 18—FLOOR OF SINGLE BARREL CYLINDER MOLDS

one man is able to put up a floor of 45 molds, including core setting, in a day of nine hours. The machines are operated in pairs, one for the cope and the other for the drag. The copes are seen set on end and the drags in the front row are in a horizontal position with the cores in place. The barrel core is set first, surrounded by the jacket core made in halves and next the small pieces are set and jigs are used to center the cores. When the molds are closed they are set on end for pouring.

The utility of the stripping plate machine for making large

molds is illustrated in Figs. 19 and 20. The pattern is a large mower frame in the form of an irregular triangle cored out to form a housing for a pair of shafts and a number of connecting gears. The casting weighs 150 pounds, is 24 x 36 inches, and is of such size and shape that the pattern can be fitted to a stripping plate machine with comparative ease, although not lending itself readily to the rock-over type. However, if the ordinary stripping plate methods were employed,

FIG. 19—STRIPPING PLATE MACHINE FOR MOWER FRAMES ROLLED OVER WITH FLASK

it would be necessary to fix bars in the drag to retain the sand while the flask is being lifted off the machine and rolled over. This would add to the expense of the equipment and would also seriously interfere with the speed of the workmen. To avoid these difficulties, the entire molding machine, with the flask in place, is turned over by a crane before the pattern is stripped out of the drag. In Fig. 19 the machine and flask are rolled-over, ready to strip the pattern. In Fig. 20 the molding machine has been rolled back into position to receive another flask. The drag half of the mold is shown at the left with

FIG. 20—DRAG HALF OF MOWER FRAME MOLD, WITH THE STRIPPING PLATE MACHINE IN RAMMING POSITION

some of the cores in place. The machines are operated in pairs, one making copes and the other drags. The ramming operation is extremely simple, the sand being merely stepped-off.

Stripping Plate for Boiler Section

The application of the stripping plate principle to machines for making boiler sections is shown in Fig. 21 and several succeeding views. In this illustration the pattern is the cope of a round boiler firepot. The machine consists of a strip-

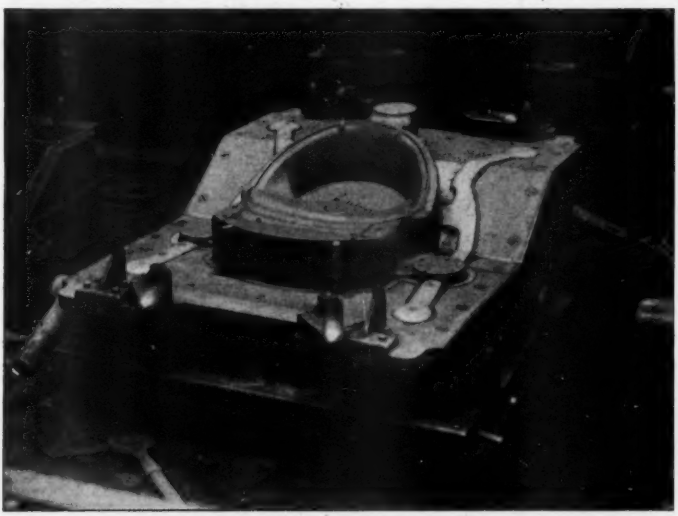

FIG. 21—STRIPPING PLATE MACHINE FOR MOLDING THE COPE OF A ROUND BOILER FIRE POT

ping plate and base. The stripping plate actuating device, shown in Fig. 22, consists of four cams, one at each corner of the machine; these are mounted on shafts placed at right angles to each other which mesh by means of mitre gears. These shafts, controlled by means of a lever, impart their motion to the four cams, causing them to elevate or lower the stripping plate.

A combination of the jar-ramming and stripping plate principle is illustrated in Fig. 23. The pattern, mounted on the jarring machine table, is for the dome portion of a round

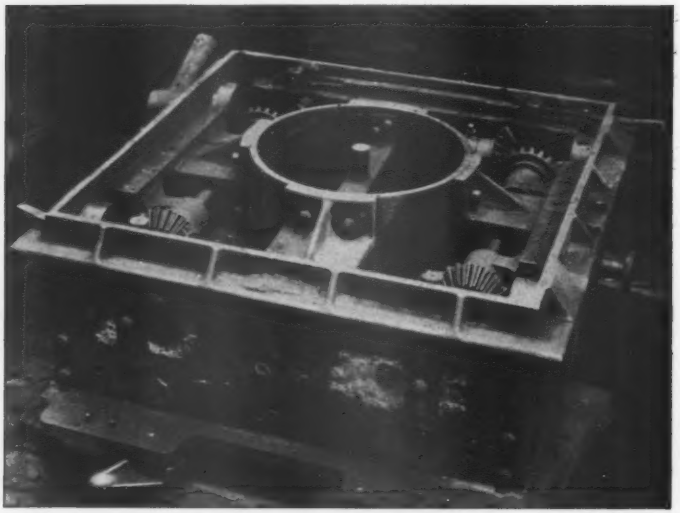

FIG. 22—STRIPPING PLATE OPERATING MECHANISM OF THE MACHINE SHOWN IN FIG. 21

FIG. 23—HOW THE JAR-RAMMING AND STRIPPING PLATE PRINCIPLES ARE COMBINED FOR MOLDING THE DOME OF A ROUND HEATING BOILER

XUM

heating boiler and the stripping plate is shown at the right. When making a mold, the stripping plate is lowered over the pattern, the flask set in position and the mold is rammed by jarring. After clamping, the stripping plate and flask are lifted off by a crane.

A larger stripping plate machine for molding the drag half of a sectional boiler is shown in Fig. 24, the pattern in this view having been stripped through the plate.

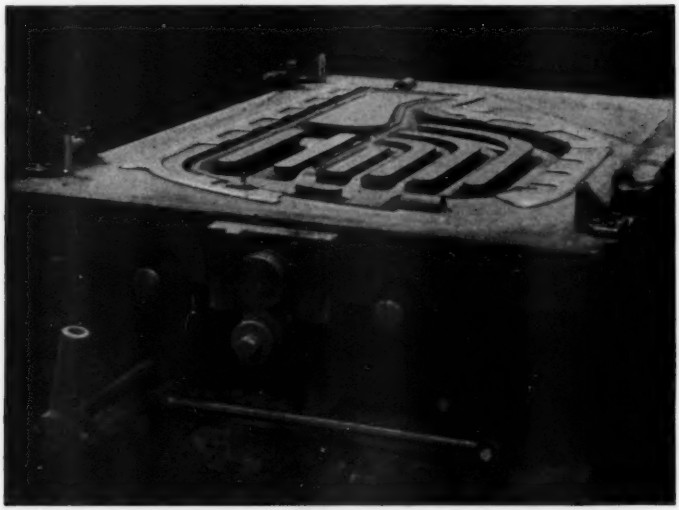

FIG. 24—LARGE STRIPPING PLATE MACHINE FOR MOLDING DRAG HALF OF A SECTIONAL BOILER

Fig. 25 shows another boiler section mounted on a large stripping plate machine with the pattern in its elevated position. The output per day is 30 molds. Two men are required on the cope machine, two on the drag machine, while one man and a helper set cores and finish the molds.

Making Piano Plates on Stripping Plate Machines

That the stripping plate machine has a widely diversified use is illustrated by its application to the molding of piano plates, as shown in Figs. 26, 27, 28 and 29. The drag is

FIG. 25—ANOTHER BOILER SECTION MOUNTED ON A LARGE STRIPPING PLATE MACHINE

FIG. 26—STRIPPING PLATE MACHINE FOR MOLDING PIANO PLATES

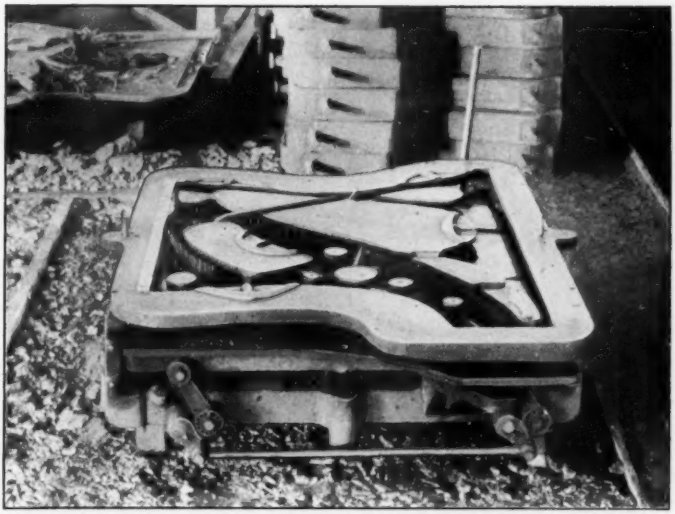

FIG. 27—PIANO PLATE PATTERN LOWERED, SHOWING STOOLS FOR SUPPORTING THE PINS

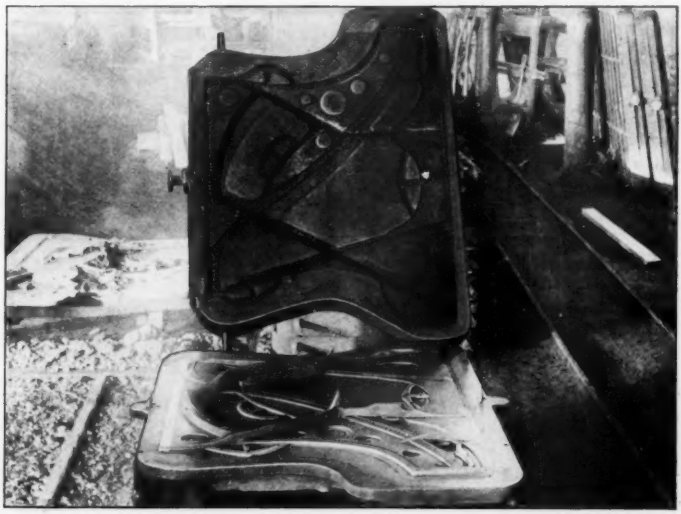

FIG. 28—DRAG HALF OF THE MOLD SHOWING THE PINS EMBEDDED IN THE SAND

molded on the machine, Fig. 26, the pins to which the strings of the piano are attached being inserted in the pattern and are delivered from it into the sand, where they are firmly embedded into the casting by the molten iron. After inserting the pins in the pattern, the drag flask is set in position and rammed. In Fig. 27 the pattern has been lowered away from the plate and the stools or spindles which support the pins are clearly shown. When the mold is lifted off the machine the pins are carried in

FIG. 29—THE COPE STAND, AND SPECIAL CAST IRON FLASKS IN THE BACKGROUND

the sand and project into the mold 5/16-inch. The drag half of the mold, with the pins protruding from the sand, is shown in Fig. 28.

Fig. 29 shows the stand on which the cope half of the piano plate mold is made. The special cast iron cope flasks are in the background. When made by hand, the daily output of piano plate molds, by a molder and helper, averages from six to seven. By the use of the stripping plate machine and the cope stand, five unskilled men produce 65 molds per day. To equal the record of machine molding would require

FIG. 30—ROCK-OVER MACHINE EMPLOYED FOR MOLDING A HEATER TOP

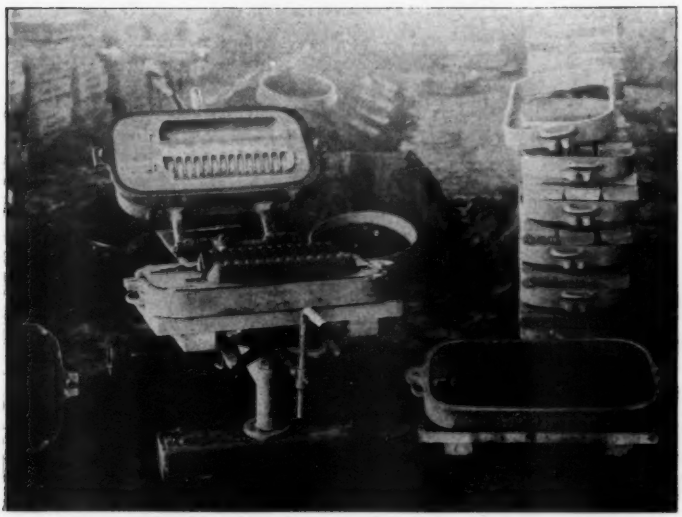

FIG. 31—ROCK-OVER MACHINE FOR MOLDING RANGE GRATES

FIG. 32—TWO HEATER DOMES ON ONE PATTERN PLATE, MOLDED ON ROCK-OVER MACHINE

FIG. 33—RANGE GRATE REST MOLDED ON ROCK-OVER MACHINE

18 men, nine molders and nine helpers, molding by hand. In addition to performing all of the necessary molding operations, the five men set the pins, which is not required of the floor molders. To expedite the work, special cast iron flasks are used which are lifted off the stripping plate machines and are rolled over by an air hoist.

The Roll-Over Machine

Almost concurrent with the development of the stripping plate machine was the roll-over type on which the mold is

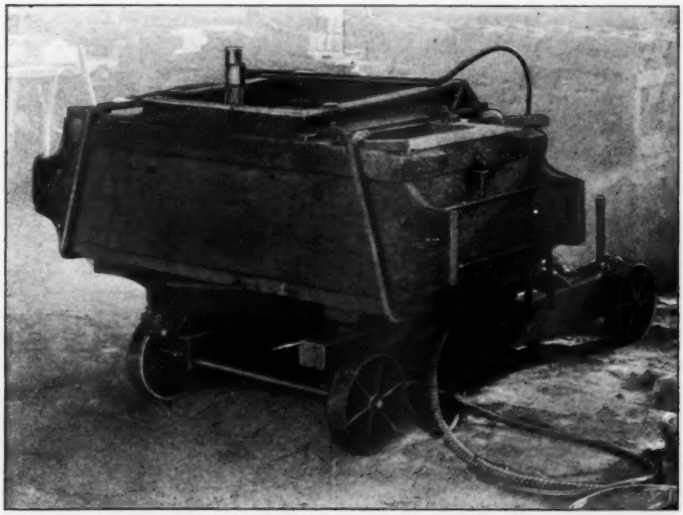

FIG. 34—HINGED POWER MOLDING MACHINE, SHOWING FLASK ROLLED OVER

rolled-over onto a leveling device before the pattern is drawn. This is effected by the upward movement of the arms supporting the pattern plate and by a continuation of this movement the pattern plate is rolled back into molding position. However, for comparatively shallow work and patterns having considerable draft, roll-over machines of the hinged type are successfully employed, no vertical movement being necessary to draw the pattern from the sand.

In Figs. 30, 31, 32 and 33, the molding of stove plate on simple roll-over machines is illustrated. Fig. 30 shows the method of making a heater top, the drag being molded on a rock-over machine, and the cope on the stripping plate machine at the left. In the foreground are shown the cope and drag halves of the mold, and it will be noted that the artistic face of the pattern has been retained in all its delicate outlines in the drag.

FIG. 35—AUTOMOBILE CRANK CASE PATTERN DRAWN FROM THE MOLD

The further application of the rock-over machine to stove work is indicated in Fig. 31. Two range grates are made in one mold, the drag being molded on the roll-over machine while the cope is made on a stand.

In Fig. 32 the drag half of two heater domes, mounted on one pattern plate, is made on a roll-over machine, the cope being molded on the stand at the right. The faces of the castings are artistic in design and the patterns of the drag are printed-back.

XUM

Fig. 33 shows a range grate rest, the drag half of which is made on a rock-over machine while the cope is molded on the stand at the right. The drag contains three dry sand cores.

The application of the hinged power molding machine to automobile work is shown in Fig. 34. The flask has just been rolled over, and after the removal of the clamps, the pattern is drawn. In Fig. 35, the bottom half of the crank case pattern has been drawn from the mold and the pattern plate is being rolled over into position for receiving another

FIG. 36—ROCK-OVER DROP MACHINE FOR MOLDING STOVE TOPS

flask. The rolling over of the flask and the drawing of the pattern are effected by compressed air.

A rock-over drop molding machine particularly adapted for molding stove tops is shown in Fig. 36. The pattern plate is bolted to a frame which is attached to adjusting guides fastened to a shaft operating in cast iron uprights, while spiral springs facilitate the rolling back of the pattern plate. The leveling of the bottom board is accomplished by four equalizing posts. The mold is rammed by hand and is lowered away from the pattern by releasing plungers which have a drop of two

inches and this together with the roll-over movement permits of handling patterns six inches deep. By increasing the length of the plungers any desired drop can be secured. Stove tops, 27 x 45 inches in size, have been successfully molded on this machine. The stand on which the copes are rammed by hand is shown at the right.

Jar-Ramming Molding Machine

The jar-ramming molding machine, in its simple form, is intended solely to eliminate hand-ramming. That it accom-

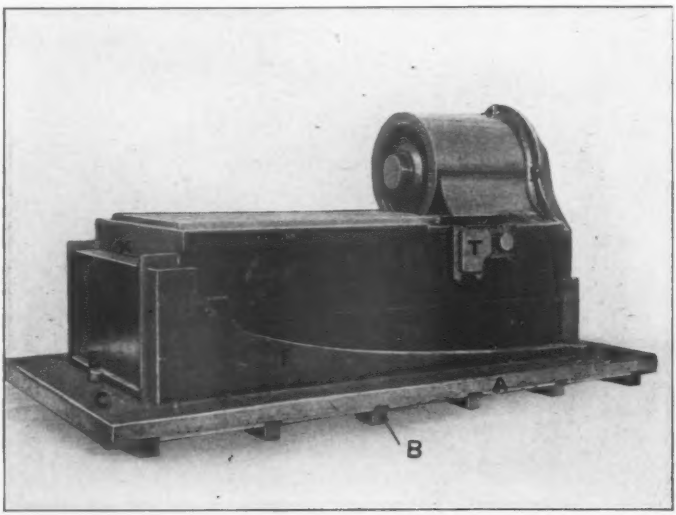

FIG. 37—HOW A BORING MILL PATTERN IS MOUNTED ON A BOARD FOR MOLDING ON A JAR-RAMMING MACHINE

plishes this effectively is reflected by its extensive use for both small and large work. These machines are operated both by electricity and compressed air and small foot-power machines are designed for ramming cores. The mounting of patterns for jar-ramming machines, to expedite the work and to preserve the models, involves many interesting problems. In Fig. 37 the pattern of a boring mill column is shown mounted for a jar-ramming operation. The pattern board, *A*, is 1½

inches thick and *B* is one of the 5 x 6-inch battens attached crosswise to the board.

Around the edge of the pattern plate is placed a 1-inch hard wood, removable strip to protect the edges. The pattern is made of 1½-inch material and is braced throughout. It is attached to the pattern board by three ¾-inch bolts, 12 inches long, which are passed through the braces. The pattern also is attached to the board with screws. The entire pattern, with

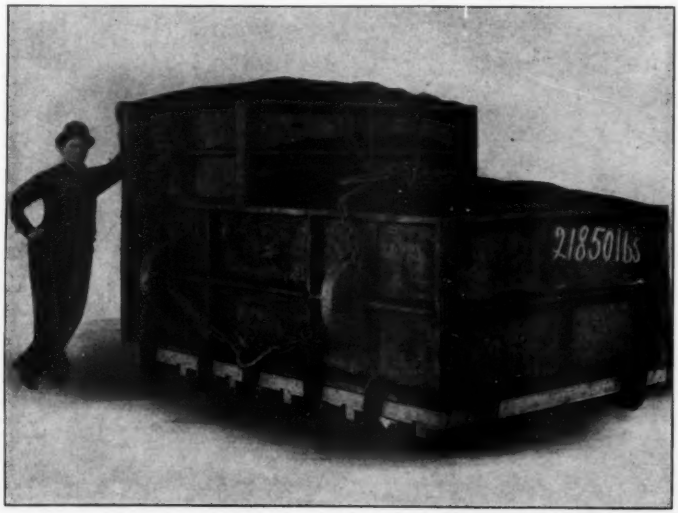

FIG. 38—MOLD FOR BORING MILL CASTING MADE ON A JAR-RAMMING MACHINE; WEIGHT, 21,850 POUNDS

the exception of the bearings, *T*, for the feed boxes, is in one piece. These boxes are drawn into the pattern after it has been rammed. The pattern is gated along the upper edge, *E*, to the two corners under the bottom and into the body of the mold at *X*. The flask, shown in Fig. 38, is made in two sections, bolted together and is provided with trunnions for rolling over. The mold weighs 21,850 pounds.

Fig. 39 shows the table of a 20-ton jar-ramming machine, practically on a level with the foundry floor. The table is illustrated at *A* and in the background is a pattern over which

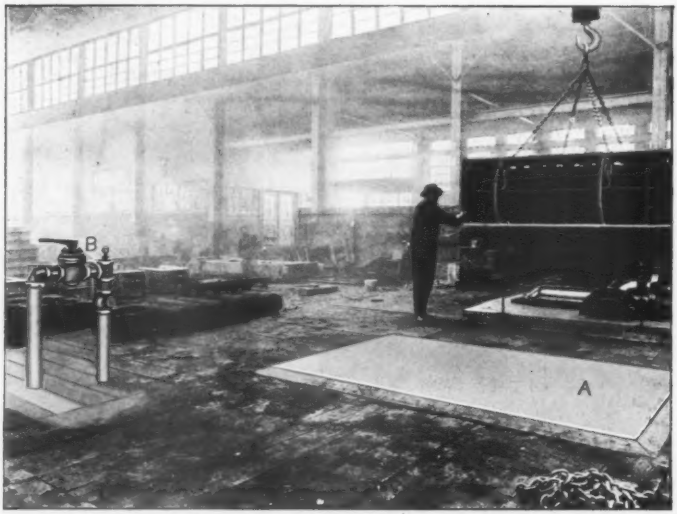

FIG. 39—TABLE OF A 20-TON JAR-RAMMING MACHINE ON A LEVEL WITH THE FOUNDRY FLOOR

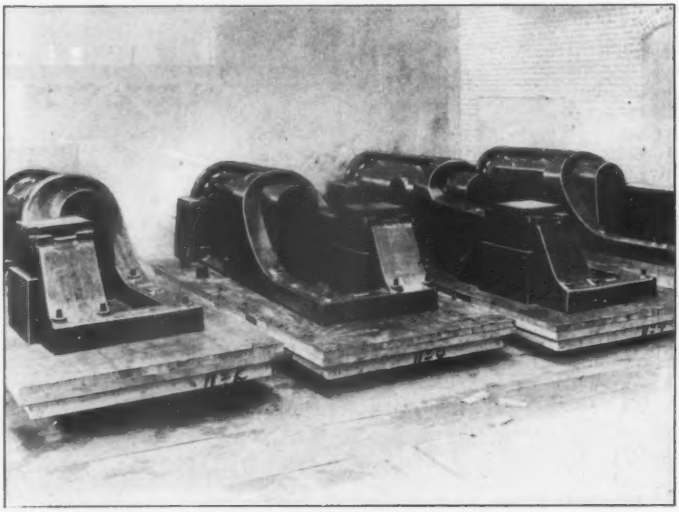

FIG. 40—HOW PATTERNS FOR ENGINE BEDS ARE MOUNTED FOR JAR-RAMMING MACHINE OPERATIONS

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a flask is being lowered to be rammed on this machine. This is an air vessel and discharge cap return for a 16-inch pump body, both drag and cope being made from the same pattern. The board to which the pattern is attached is built on three battens and is 7 feet wide and 10 feet long. The table of the machine is 6 x 9 feet.

Patterns for engine beds, showing the method of mounting on boards for molding on jar-ramming machines, are illustrated in Fig. 40.

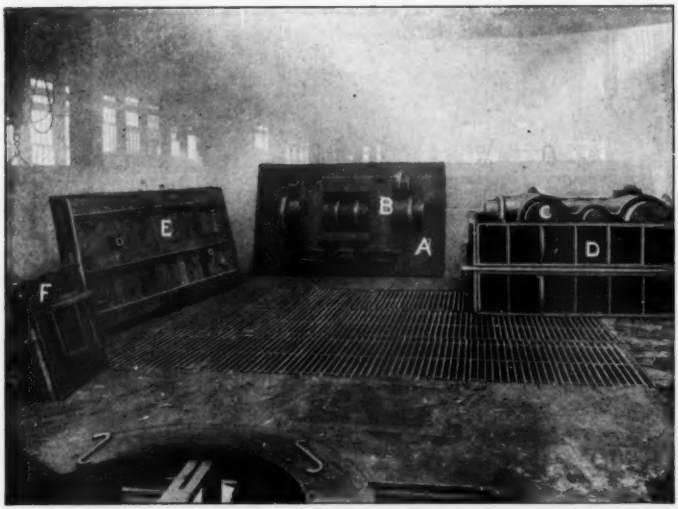

FIG. 41—ONE PATTERN BOARD SERVES FOR TWO PATTERNS

In Fig. 41, *B* and *C* are two halves of a large pump body pattern molded on a jar-ramming machine. The drag and cope parts of this pattern can be detached from the board, *E*, to which both patterns can be fastened. The patterns are attached to the board with dowel pins and screws. The board for this pump body pattern has four 4 x 9-inch battens instead of three, as on the engine bottom boards, but otherwise the construction is the same. In the foreground is shown a grating, two of which are located in this foundry, one opposite each jar-ramming molding machine. The flasks are shaken-

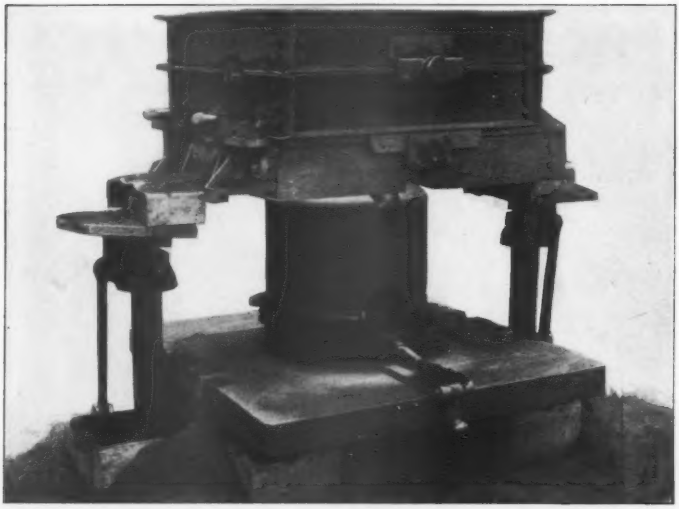

FIG. 42—HOW THE STRIPPING PLATE IS USED IN COMBINATION WITH THE JAR-RAMMING MACHINE

FIG. 43—COMBINATION MACHINE FOR MOLDING PISTONS

out over the gratings, the sand falling into a pit underneath the floor.

Combination Jar-Ramming Machines

Fig. 42 illustrates the use of the stripping plate mechanism on a jolt-ramming machine. This shows the cheek only, the cope having been removed. This is another application of machines of the jolt-ramming type to the molding of boiler sections.

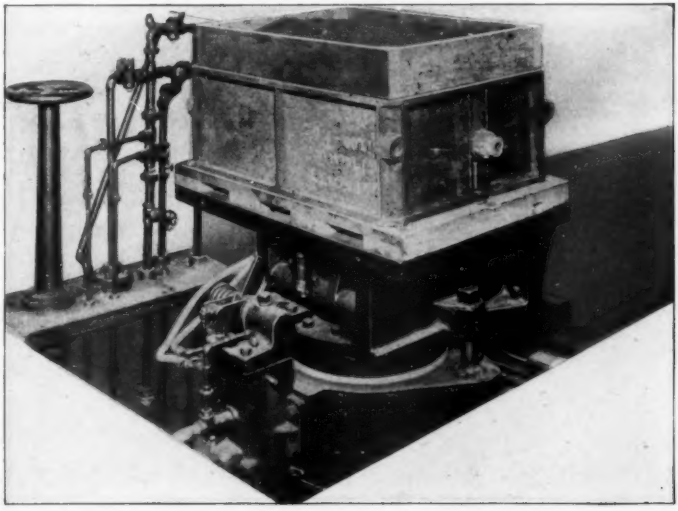

FIG. 44—COMBINATION SHOCKLESS JAR-RAMMING, ROLL-OVER AND PATTERN-DRAWING MACHINE WITH FLASK IN RAMMING POSITION

Fig. 43 shows another type of combination jar-ramming machine especially designed for molding pistons. It is of the jar-ramming, roll-over, pattern-drawing design, and aside from filling the flask with sand, practically all the operations are mechanically performed. The drag half of the mold with the cores in place is on the stand directly in front of the machine. The copes are rammed on a bench on an iron cope pattern plate. The daily output of two men is 125 molds containing four pistons each, or a total of 500 pistons. When made by

hand the output was 200 pistons. Each mold contains 38 pounds of metal and the entire floor aggregates 4,750 pounds.

A combination shockless jar-ramming, roll-over and pattern-drawing machine is shown in Figs. 44, 45, 46 and 47. It accomplishes all of the molding operations with the exception of filling the flask with sand and lifting off. It is claimed that only sufficient foundation is necessary to carry the dead weight of the machine together with that of the flask to be handled. The machine is operated by compressed air and all

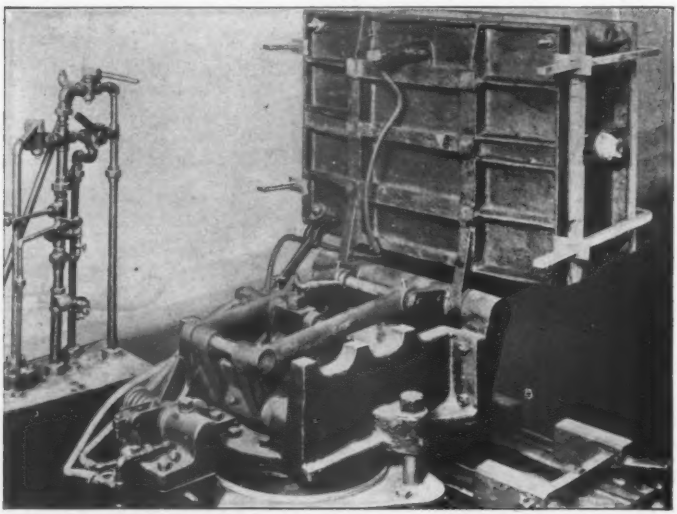

FIG. 45—ROLLING-OVER THE MOLD

of the movement are controlled by the levers at the side. In Fig. 44 the flask has been filled with sand, a sand frame being shown on top of the flask. After ramming and clamping, the mold is rolled over, as shown in Fig. 45, and in Fig. 46 the flask has been leveled, the clamps removed and the pattern is being drawn. In Fig. 47 the pattern has been rolled back onto the jarring machine table, ready to receive another flask, and the mold just made is ready to be lifted off.

There seems to be no limit to the accomplishments of combination types of molding machines, regardless of the

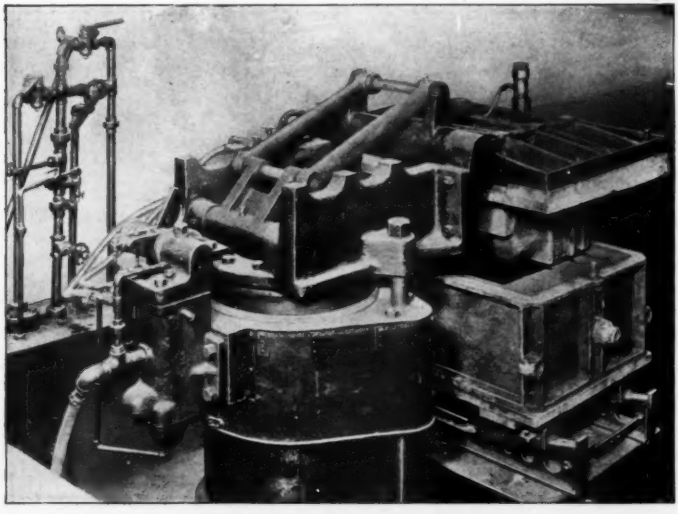

FIG. 46—DRAWING THE PATTERN

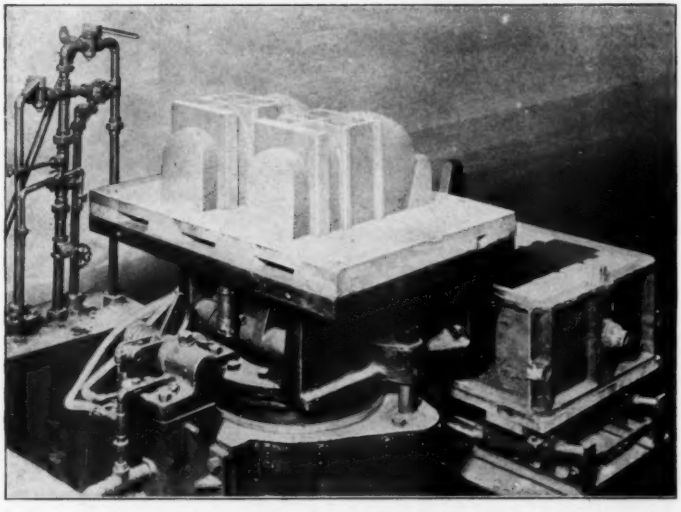

FIG. 47—PATTERN RETURNED TO MOLDING POSITION ON THE JAR-RAMMING TABLE

intricacy of the pattern. Fig. 48 shows a four-cylinder crank case and fly wheel housing for the power plant of a motor truck. The pattern is mounted on a jar-ramming, roll-over pattern drawing machine. The molds are made by a crew of seven men, 33 constituting a day's output. One mold is finished in 15 minutes. When made by hand, one .mold constituted a day's work for a molder whose sand was cut by a laborer and the output of the machine and its crew of seven men per

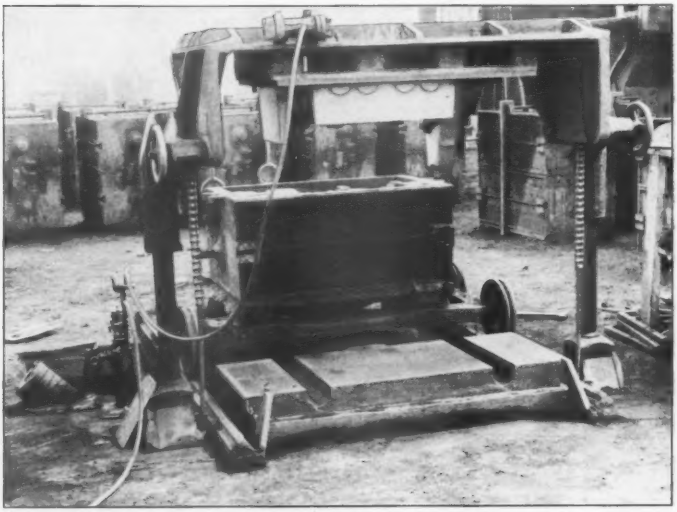

FIG. 48—JAR-RAMMING, ROLL-OVER, PATTERN-DRAWING MACHINE FOR MOLDING A FOUR-CYLINDER CRANK CASE AND FLY WHEEL

day is equal to the production of 33 molders and four laborers operating by hand. The machine crew consists of five molders and two helpers. One of the helpers shovels the sand into an electrically-operated riddle while the other fills the flasks. Two molders are employed in making the drags and copes, two set cores and one is required for finishing the molds. This view shows the cope pattern drawn from the mold, which rests on a buggy operating on a track on which it is drawn out from underneath the machine for delivery to

the floor by a crane. Fig. 49 shows the cope half of the mold tilted and ready to be delivered to the floor by a crane.

A six-cylinder crank case and fly wheel housing pattern which also is made on a machine of the type previously described, is shown in Fig. 50. The four-wheel truck, which contains the mold leveling device, is shown in the foreground.

Team Work in Machine Molding

What can be accomplished by team work in molding machine operations is illustrated in Figs. 51, 52, 53, 54 and

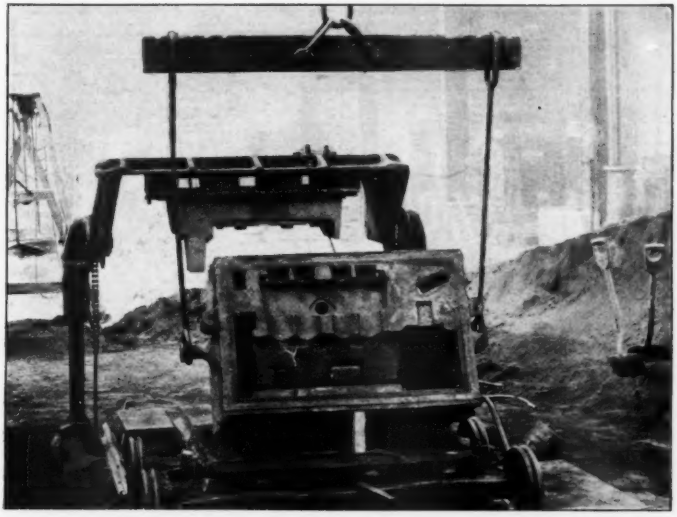

FIG. 49—THE COPE HALF OF THE FOUR-CYLINDER CRANK CASE MOLD

55. The machine is of the combination, 13-inch, jarring, hinged, roll-over type, which rams the mold, rolls over the flask and draws the pattern without the use of cranes or hoists. This is a particularly noteworthy accomplishment in view of the fact that the flask weighs 4,000 pounds and the machine is manned by unskilled labor. The pattern plate is provided with swivel cam clamps for holding the flask to the plate while rolling over. The flask is located on the pattern plate by three pins which fit in holes drilled in the flanges of the flask. The

equipment for handling flasks and bottom boards consists of an eye bolt hooked on one end, the eye passing over the crane hook and the hooked end passes through holes in the bottom board. An overhead traveling crane handles the flasks, bottom boards, removes the finished molds and does the closing. A gang of night men shakes out the molds, prepares the sand and piles the bottom boards and flasks convenient to the machine ready for use by the machine gang. The team consists of four

FIG. 50—SIX-CYLINDER CRANK CASE AND FLY WHEEL HOUSING PATTERN MOUNTED ON COMBINATION MACHINE, FIG. 48

operators and two mold finishers. For convenience in reference the team will be classified and numbered as follows: No. 1, operator or man who controls the power operation; Nos. 2, 3 and 4, helpers; Nos. 5 and 6, mold finishers.

After helper No. 3 has placed the crane hooks on the flask trunnions the flask is swung over the pattern plate on the machine and is guided into place onto pins by operator No. 1 and helper No. 2. Operator No. 1 then gives the machine one jar to settle the flask on the pattern, after which helpers Nos.

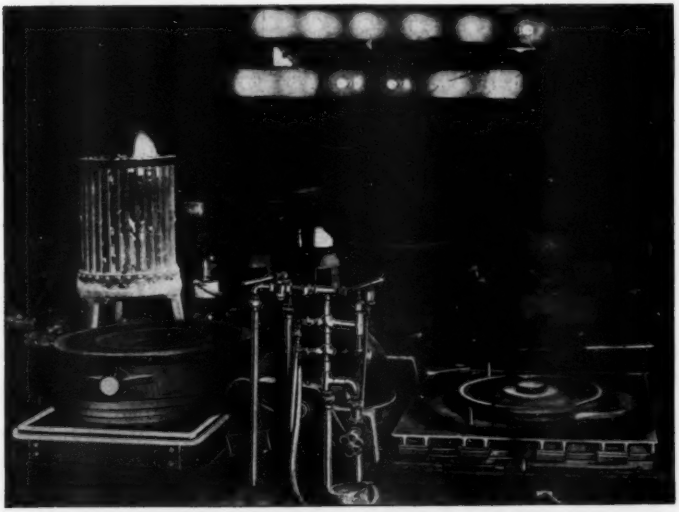

FIG. 51—JAR-RAMMING, HINGED, ROLL-OVER MACHINE FOR MOLDING CAR WHEEL CENTERS

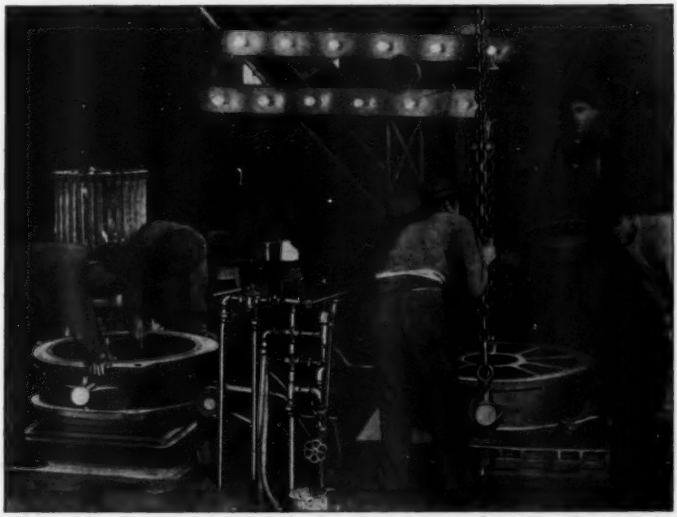

FIG. 52—COPE FLASK BEING MOUNTED ON THE MACHINE AT THE RIGHT AND COPE MOLD BEING FINISHED AT THE LEFT

1 and 3 clamp the flask to the pattern plate. Helper No. 4 then riddles the facing sand over the pattern, after which he shovels in the facing sand while operator No. 1 distributes it over the pattern. Helper No. 3 sets gaggers, assisted by operator No. 1 and helper No. 4. Helper No. 2 in the meantime is hooking the bottom board to the crane, helpers Nos. 3 and 4 place the sand frame on the flask and all four men shovel the sand into the flask. Helper No. 2 levels the sand

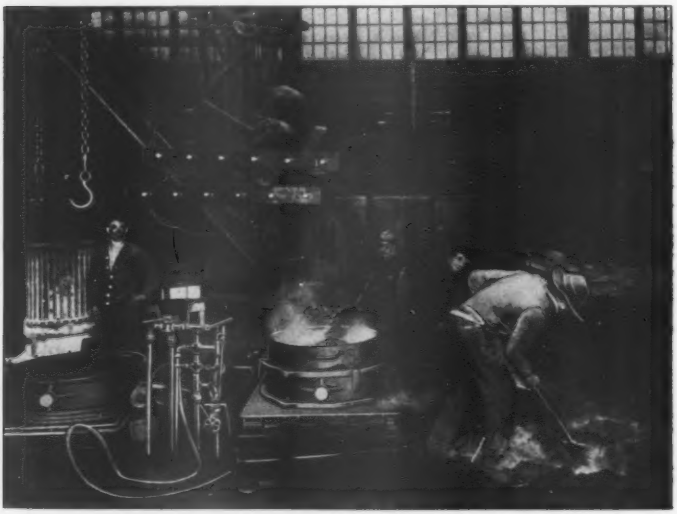

FIG. 53—FLASK BEING FILLED WITH SAND

in the frame while operator No. 1 operates the jarring machine, giving the cope 21 blows and the drag seven blows, depending upon which half is being rammed. Helpers Nos. 2 and 4 remove the sand frame and strike-off the mold while the crane brings up the bottom board. In the meantime helper No. 3 has picked up two eye bars, one of which he inserts into a hole in the bottom board, and the other he hands to helper No. 4, who in turn inserts it into an adjacent hole in the bottom board, while it is being swung into place over the flask. As one edge strikes the flask and tilts over it is guided

into place by helpers Nos. 3 and 4, who insert the eye bars into two holes in the flask flange, so that the holes in the bottom board drop in line with the holes in the flask. While this is taking place, operator No. 1 takes the crane hook, removes the eye hook, thereby releasing the bottom board from the crane, after which he gives the machine one jar to settle the bottom board upon the flask. In the meantime helper No. 3 has picked up three bolts, nuts, washers, wrenches and wedges,

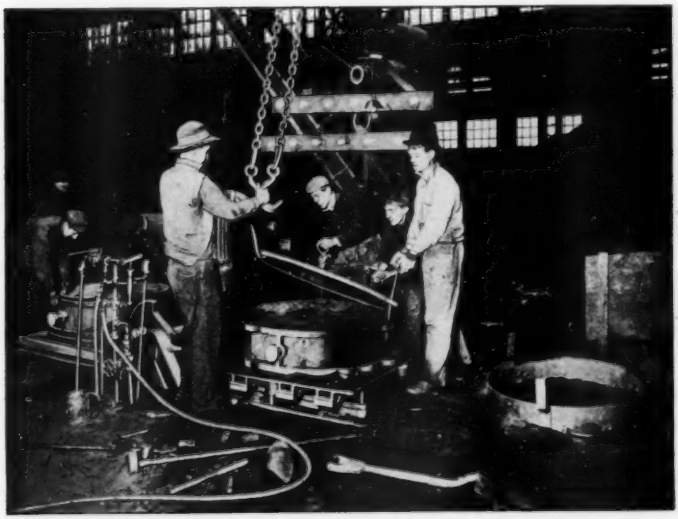

FIG. 54—METHOD OF LANDING BOTTOM BOARD ON RAMMED MOLD

which he deposits on the center of the board and operator No. 1 and helpers Nos. 2 and 3 bolt the bottom board to the flask and drive wooden wedges between the flask and bottom board to prevent them from closing under the weight of the cope flask.

In the meantime helper No. 4 gets facing sand, bolts or anything else that may be needed. Operator No. 1 then rolls over the hinged frame and with the blow valve blows off any loose sand that may have accumulated on the table of the jarring machine. As soon as the flask settles down upon the

equalizing cradle the flask clamps are released by helpers Nos. 2 and 3. The cradle is vibrated so that the flask will rest concentric with the line of draft after the clamps are released. After releasing the clamps, operator No. 1 starts the vibrator and draws the pattern. The hinged frame carrying the pattern plate and pattern then rolls back to its original position on the jarring machine.

As soon as the pattern has been drawn from the mold,

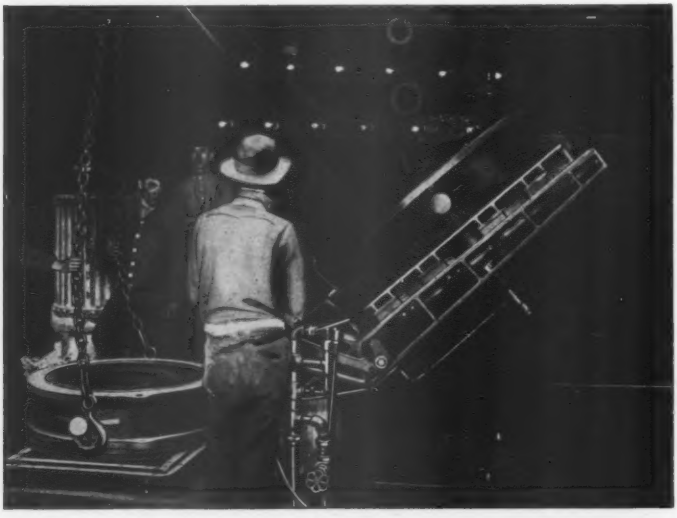

FIG. 55—ROLLING-OVER RAMMED MOLD AS THE CRANE IS ABOUT TO REMOVE FINISHED MOLD

finisher No. 5 finishes the mold while finisher No. 6 brings up and assists in setting the cores and chaplets. While the hinge frame is rolling back, helper No. 2 has attached another empty flask to the crane and as the flask is being conveyed to the machine, helper No. 3 cleans the pattern and pattern plate with a blow-off valve. The flask then is placed in position on the pattern plate and the team repeats the foregoing operations. After depositing the flask on the machine, the crane brings up another bottom board, then moves over to the completed mold and transfers it to the floor ready to receive the

cope half, if the mold happens to be the drag. Finisher No. 6 closes the mold, and after setting the runner boxes in place, returns in time to assist No. 5 in setting the core in the next mold. The time required to do this work varies from four to five minutes and the team manages to put up regularly 50 copes and 50 drags for a day's work. In Fig. 51 the machine is ready to receive the flask at the right and the finished mold is shown at the left.

FIG. 56—RADIATOR MOLDING MACHINE

In Fig. 52 the cope flask is being mounted on the machine at the right and the cope mold is being finished at the left.

Fig. 53 shows a sand frame on the flask which is being filled with sand, the four operators shoveling simultaneously, and at the left the crane hooks are being dropped to receive the flask.

Fig. 54 illustrates the method of landing the bottom board on the rammed mold at the right. At the left the finishers are putting the last touches on the mold. In Fig. 55 the rammed

mold is being rolled over as the crane is about to remove the finished mold.

Machine Molded Radiator Loops

The molding of radiator loops has been developed to a high state of mechanical efficiency. In some foundries exceedingly ingenious continuous plants have been installed which ram the molds by machine and complete the entire cycle of operations including pouring and shaking-out. However, in smaller

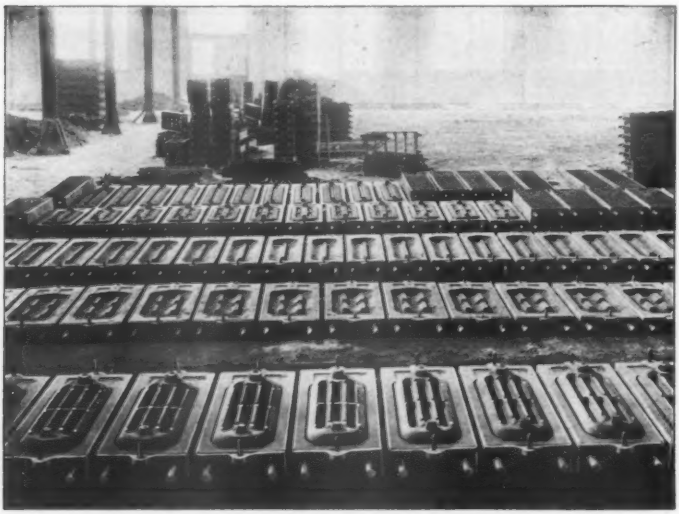

FIG. 57—FLOOR OF RADIATOR MOLDS

shops, simple machines are employed which perform the work economically and at a fraction of the cost of hand molding. A machine of this type is shown in Fig. 56. The molds are rammed by hand, and the table on which the pattern is mounted, being stationary, the mold is lifted from the pattern by four flask bars operated by the lever at the left. The radiator chaplets, which are inserted in openings in the pattern prior to making the mold, are clearly indicated.

A floor of radiator molds, showing loops of various types, is illustrated in Fig. 57. In the foreground the cores have been

set in place and the white spots on the cores are small pieces of tin which prevent the chaplets, protruding from the face of the cope, from sinking into the core.

An English type of electrically-operated radiator molding machine is shown in Fig. 58. The machine is practically automatic and when the motor is set in motion, the machine rams the mold and draws the pattern, the electric current being switched off automatically. The output is approximately 80 to 100 castings per day with three operators, two men attending

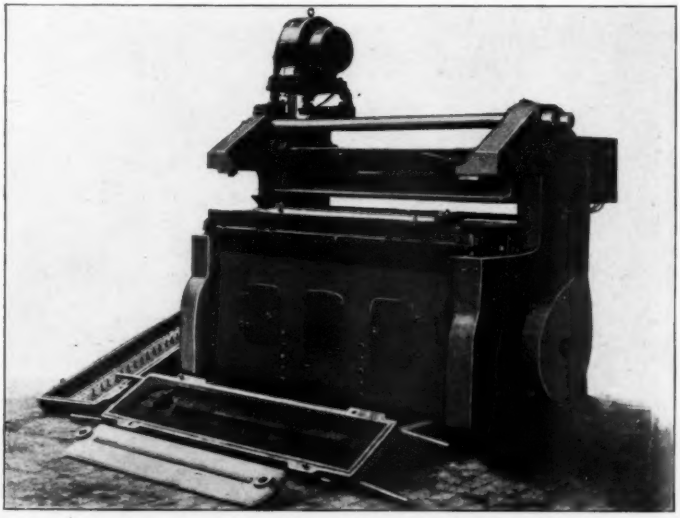

FIG. 58—ENGLISH RADIATOR MOLDING MACHINE

the machine while the third closes the flasks and pours the molds. What are termed as *closed flasks* are used on this machine, the bottoms being perforated to permit the gases to escape. By the use of these flasks less sand is required and they can be inclined when the metal is being poured without being clamped to the bottom boards; they also require no weighting.

Gear Molding Machines

Gear molding machines were among the earlier accomplishments of molding machine manufacturers and these are in

extensive use today. Fig. 59 shows one of these machines engaged in molding an 8-foot spur gear. The teeth are molded much more accurately than they possibly could be done by hand and the spacing is all that could be desired, the machines being equipped with an indexing mechanism similar to that used on a gear cutting or milling machine. Even when the teeth of gears are to be machined, those molded mechanically are to be preferred to those molded by hand. The machine con-

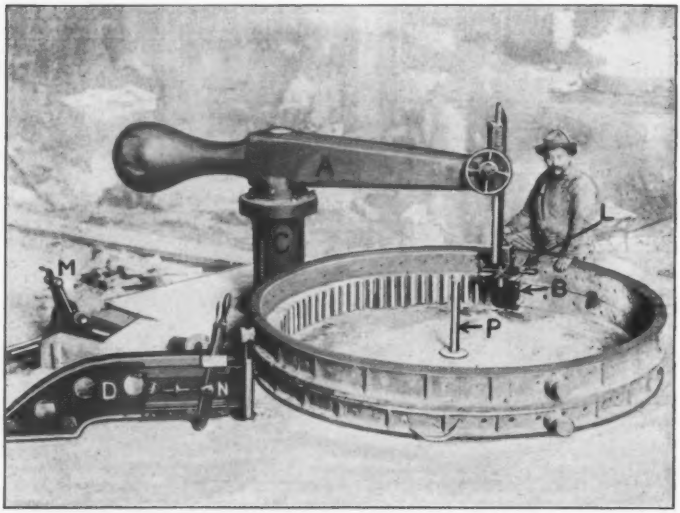

FIG. 59—MACHINE FOR MOLDING SPUR GEARS

sists of a supporting column, *C*, with a counterbalanced arm, *A*, carrying the tooth block, *B*. The latter slides vertically in gibs at the end of the arm. It also slides horizontally, this motion being controlled by the lever, *L*, which is operated when the block is drawn from the mold. If the gear is less than 8 feet in diameter, the mold is placed on the revolving table, which is rotated by the indexing mechanism, *M*. This has change gears for any number of teeth and for a gear of any diameter. If the gear is more than 8 feet in diameter, the arm, *A*, is removed and the supplemental arm, *D*, is pivoted

on the post, *P*. The tooth block is fastened to this arm, which has a horizontal motion, as indicated at *N*. In this case, the flask remains stationery, the arm being swung on the pivot, *P*, and is spaced by means of the indexing mechanism, *M*. The tooth block, which is removable, consists of an accurate pattern of one tooth and space. In making the mold the flask is set in position and the bed is swept. If the gear is shrouded, the

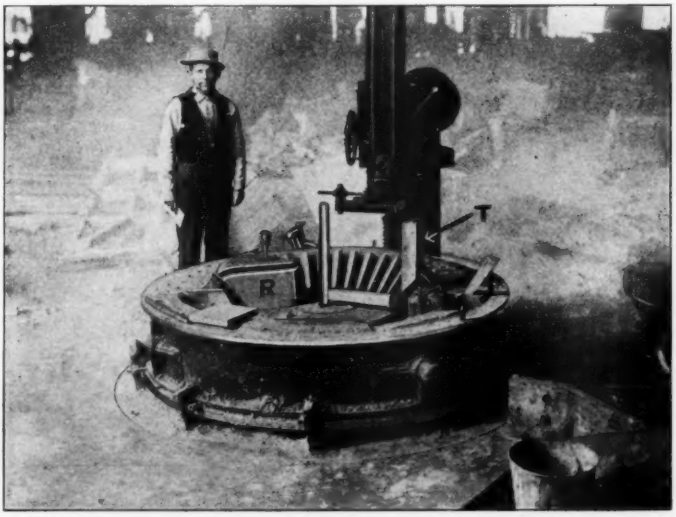

FIG. 60—MACHINE FOR MOLDING BEVEL GEARS

lower shroud is swept with the bed, the upper shroud being formed by a core. The teeth then are molded one by one, using the tooth block and indexing mechanism as described, the sand being carefully tucked in around the block each time to insure a properly rammed, accurate mold.

In the case of a bevel gear, as shown in Fig. 60, the bed is swept the same as for a spur gear. A specially-formed tooth block, *T*, is used. The back and face of the bevel gear are formed by wedge-shaped dry sand cores, one of which is

shown in place at *R*. In all other respects the molding of spur and bevel gears is similar.

Roller-Ramming Machine

Another distinct type of machine, utilizing the roller-ramming principle is shown in Fig. 61. It is well adapted to flat work and in this view a pattern for a soil pipe flask is mounted on the table. A sand frame is set over the flask and when

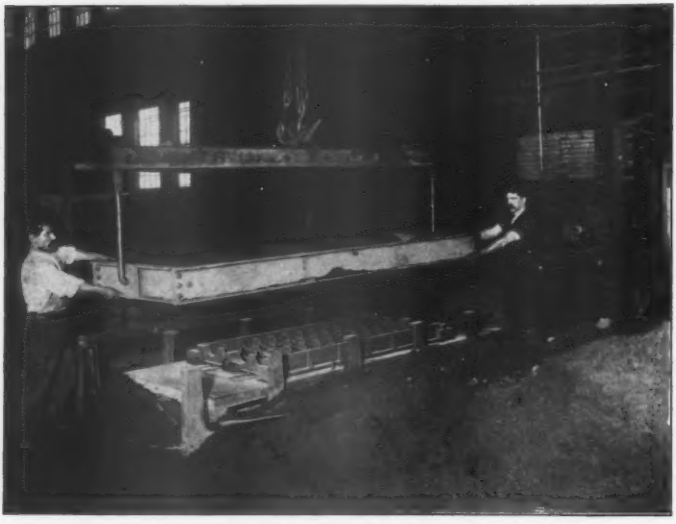

FIG. 61—ROLLER-RAMMING MOLDING MACHINE

this and the flask have been filled with sand a large, flexible, wood pad, which practically covers the full area of the flask, is placed upon the sand frame. The lower side of the pad is cut out to conform to the lines of the pattern, which, with the flexibility of its construction, contributes toward the uniform ramming of the mold, in that the depth of the sand is regulated over the contracted parts of the pattern and every part receives the proper pressure. When the pad is in position, it projects about 4 inches above the top of the sand frame. The pad communicates the force of the ramming

movement downward and at the same time it prevents the sand from being pushed forward under the impact of the roller. The roller is passed over the pad several times, forcing the latter vertically into the sand frame and ramming the sand into the flask. The roller is propelled over the pad by a long arm.

Fig. 62 shows a new roller-ramming and pattern-drawing machine. It is adapted for architectural, stove plate, textile, agricultural implement, soil pipe and similar types of castings.

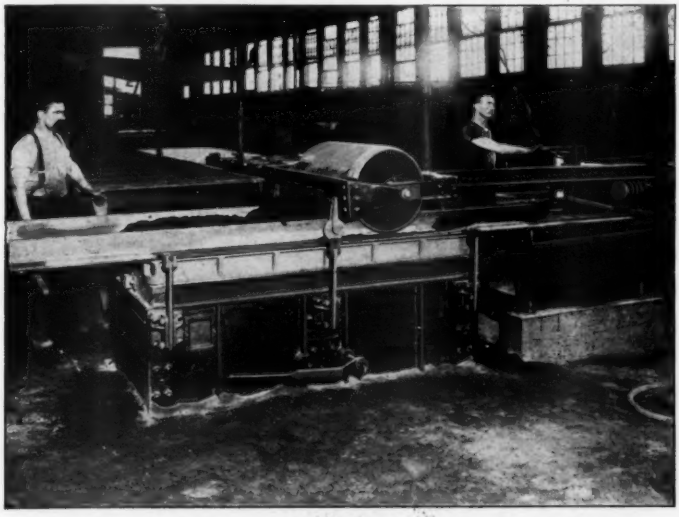

FIG. 62—ROLLER-RAMMING AND PATTERN-DRAWING MACHINE

The pattern-drawing mechanism is operated by the hand lever at the side and the strike-off is shown in front of the roller.

Gravity Molding Machine

Fig. 63 shows the gravity type of molding machine which involves a distinct principle of ramming effected by dropping the sand from a height onto the pattern in the flask. The sand is carried in buckets which descend into a hopper below the floor, where they are loaded, and the sand then is elevated, being compressed in the buckets by an automatic rammer

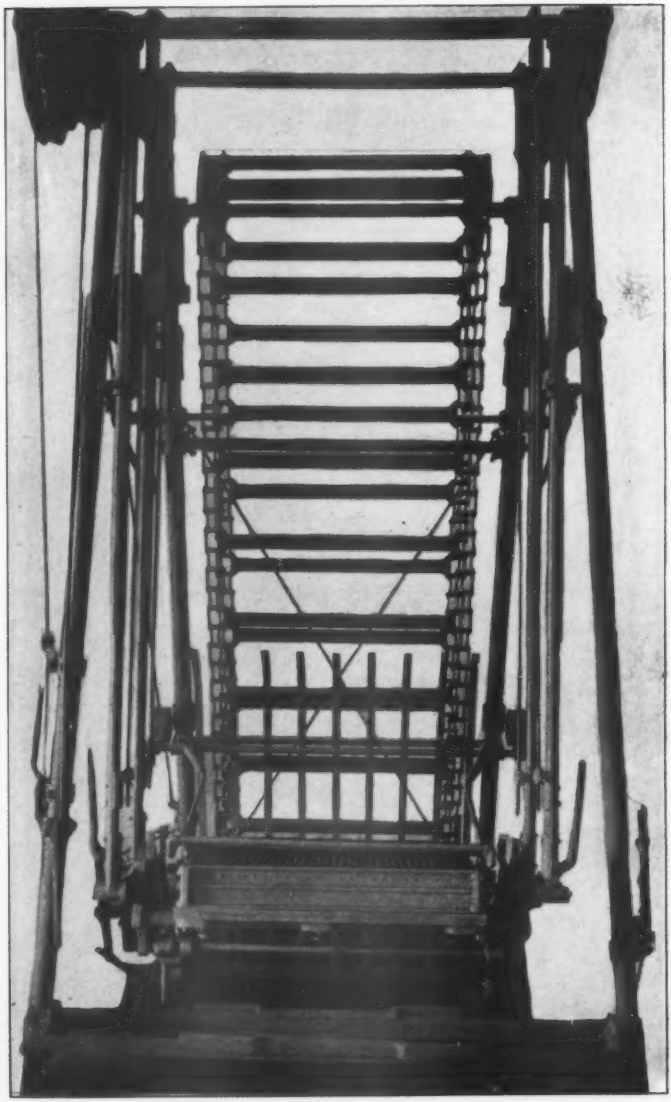

FIG. 63—GRAVITY MOLDING MACHINE

during its ascent and is dropped from the top of the elevator to the flask carried on a swinging cradle which can be rocked back and forth to secure an even distribution of the sand as it falls from the buckets. The cradle also can be raised and lowered to discharge the mold and draw the pattern. Below the floor, directly underneath the cradle, is a hopper covered with a shaking riddle into which sand is shoveled and from which it

FIG. 64—AUTOMATIC MOLDING MACHINES IN A JOURNAL BEARING PLANT

is discharged into the hopper, where it is fed to the buckets by a feed roll. When the flask has been filled, the superfluous sand is removed with a strike-off, and after the bottom board has been adjusted, the flask is clamped to the cradle, rolled over and the mold is deposited on a leveling device underneath the cradle. After the flask has been unclamped the cradle is drawn vertically upwards, thus drawing the pattern from the mold. The cradle is then lowered to its operating position, the pattern board rolled over, another flask is adjusted and the operation is repeated.

To complete the entire cycle of molding operations, several types of automatic machines have been introduced, which fill the flasks with sand, ram the molds and draw the pattern. An installation of several of the earliest types of these machines in a foundry specializing in journal bearings is shown in Fig. 64. The molds are shown in the foreground, and in the background, at the right are shown the two automatic machines. In addition to filling the flask, pressing the mold and vibrating

FIG. 65—ANOTHER TYPE OF AUTOMATIC MOLDING MACHINE

the pattern plate, the flask is moved forward, ready to lift off. A power riddle is attached to the rear of the machine and sand is conveyed by an elevator to the hopper which can be adjusted for different sized flasks. The table on which the pattern is secured travels backward and forward and is automatically stopped at the front of the machine to allow the operator to place the flask in position. The operator then presses his foot on the starting lever, a board is placed in position and the table travels beneath the hopper from which the flask is filled with sand. The surplus sand then is

struck off, the mold is squeezed, the vibrator is started automatically and the flask is raised by an air cylinder. This machine will produce from 60 to 75 molds per hour and is adapted for split patterns and stripping plates only.

Another type of automatic molding machine is shown in Fig. 65. Sand is delivered to the hopper over the machine by an elevator which is partially enclosed. The sand is screened by a flat riddle in the hopper, and to break the drop of the

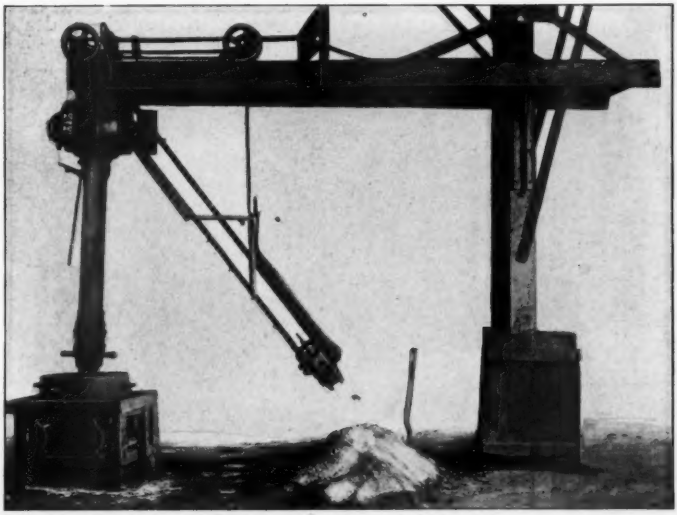

FIG. 66—MOLDING MACHINE WHICH PROJECTS SAND AGAINST THE PATTERN FROM A CONVEYOR

sand and to prevent it from packing too finely against the center of the pattern, screens are provided, which are suspended about 3 feet above the pattern plates. Both cope and drag halves of the mold are made in one operation, and after the snap flasks have been set in position, the movement of a lever permits the sand to drop from the hopper into the flasks, a distance of about 4 feet. After the flasks have been filled, the automatic strike-off moves forward, removes the superfluous sand which is carried by a belt to the boot of the conveyor. The cope

and bottom boards then are adjusted, the molds are rammed and the patterns are vibrated. The operator next adjusts the automatic clamps on the flask, the molds are rolled-over and are deposited on a carrier for delivery to the floor.

Fig. 66 shows another type of molding machine, which packs the sand in the flask by projecting it against the pattern at a high velocity. The principle employed for packing is similar to that governing the movement of the hand molder who frequently throws balls of sand pressed in the hand, against the pattern to insure a proper density of the sand in deep

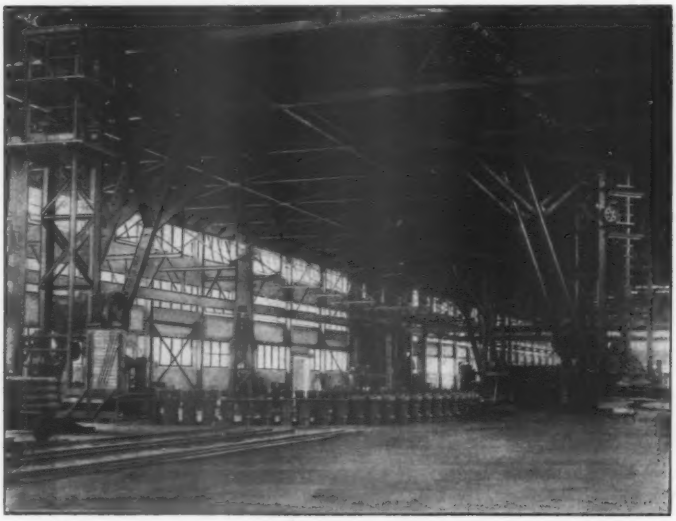

FIG. 67—CONTINUOUS CAST IRON PIPE MOLDING AND CASTING PLANT

pockets and over irregular surfaces. For projecting the sand into the flasks and against the pattern, a belt conveyor is used, provided with cleats at regular intervals. The sand is delivered to this belt by a screw conveyor, which receives its supply from another belt conveyor, the lower end of which is located over the sand pile. This machine is intended to eliminate hand-ramming and in this instance the mold is made on the stripping

plate machine shown at the left. The operating mechanism is carried in a rocking frame supported by a four-wheel truck which travels upon parallel lateral arms, and by the movement of this truck, molds can be rammed at any point within the radius of the machine. At the left of this illustration the sand-projecting belt conveyor is directly over the stripping plate machine.

Machine-Molding Cast Iron Pipe

To minimize hand labor in the manufacture of cast iron pipe several types of continuous molding and casting plants

FIG. 68—CASTING THE PIPE

have been devised. At Scottdale, Pa., the United States Cast Iron Pipe & Foundry Co. has installed a plant with a capacity of approximately 750 tons daily. It was necessary, of course, to adhere to the pit method generally employed, but tables have been installed on which the flasks revolve for the successive molding, drying, casting and shaking-out processes. Fig. 67 shows one of these tables. The molds are rammed by an electrically-operated machine in the center of the floor. Four

casting pits have been installed in two units, each served by three jib cranes. The crane which serves the rammers of each pit removes the flasks after the molds have been poured, and balances them horizontally on skids over the sand pit where the clamps are removed and the pipe shaken-out. The sand is tempered in the pit and is removed by the same crane and delivered within reach of the molding machines.

Another continuous process for the manufacture of cast

FIG. 69—THE FLASKS PASSING OVER GAS BURNERS

iron pipe is shown in Figs. 68, 69, 70, 71 and 72. In Fig. 68 the molds are being poured, the core arbors protruding from the flasks, which are vertically suspended from four parallel tracks. The flasks are mounted on four wheels fixed on axles, forming trucks on which they are carried. The flasks are divided longitudinally and each half is carried on a small wheel operating on the upper side of each axle to permit of opening it when shaking-out the casting. The rails are on a level with the foundry floor and the flasks are suspended in a pit extending the entire length of the continuous plant. In the pit also

are located the hydraulic molding machine, gas burners for drying the molds and the sand tempering and preparing plant.

Fig. 69 shows the method of suspending the flasks, which are on the drying track, showing the gas burners underneath the molds.

Fig. 70 is a view of the sand platform over the molding machine, showing the two measuring tubes with the transfer car at the left. When making a mold, sand is filled into the

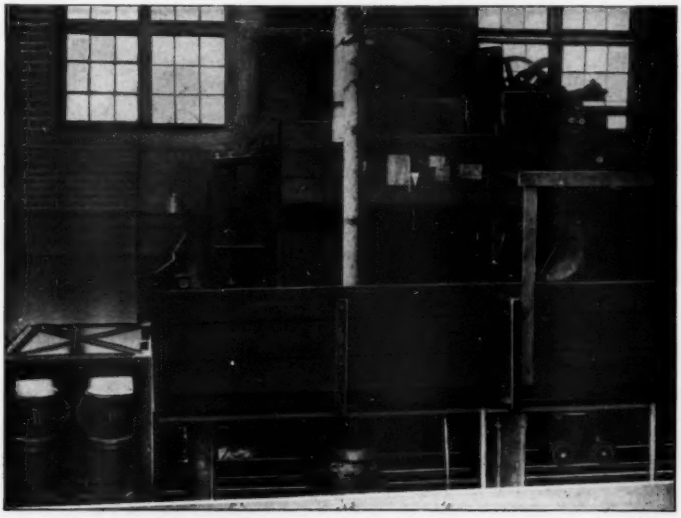

FIG. 70—SAND PLATFORM OVER THE PIPE MOLDING MACHINE

flask around a measuring tube and the sand is rammed by the upward movement of the hydraulic piston of the molding machine. The mold then is moved forward onto a transfer car operating on a track at right angles to the main runway and extending the width of the continuous plant. The flask then is transferred to the mold drying track and after the blacking is applied, it is permitted to pass slowly over the gas burners in the pit to dry the mold. At the end of this track, and after having passed over the gas burners, the flask again is moved onto a transfer car and is delivered to the first track from

FIG. 71—SHAKING-OUT THE PIPE

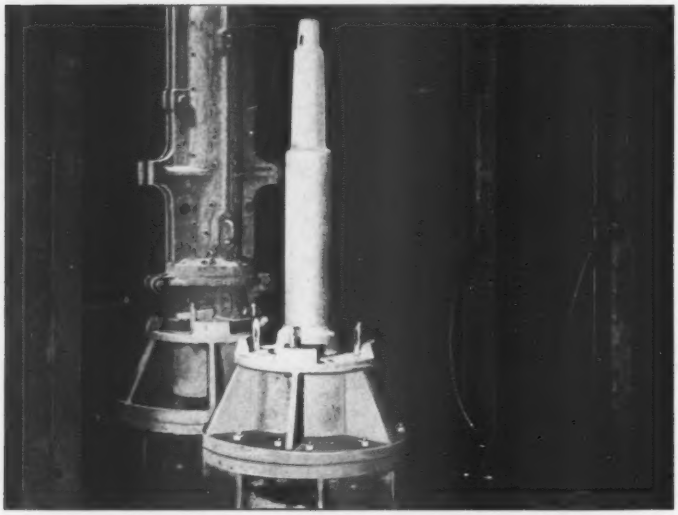

FIG. 72—THE CAST IRON PIPE MOLDING MACHINE

which it was suspended while the mold was rammed. After attaching the bottom plate, the core is set by a traveling crane and the flask is again moved forward into position for receiving the metal. After casting, the core bar is pulled out and after opening the flask the casting is withdrawn by a crane, the shaking-out operation taking place directly over the sand preparing and tempering plant in the pit. The flask then is

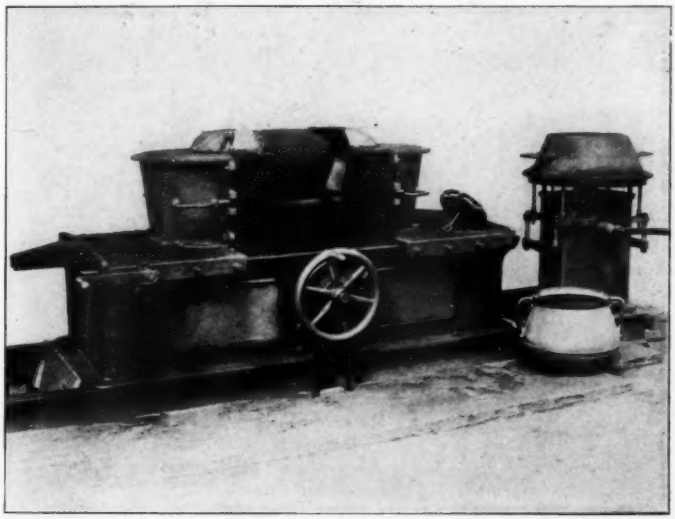

FIG. 73—GERMAN MACHINE FOR MOLDING HOLLOW-WARE

closed and is moved forward to the molding machine; the cycle of operations is repeated without cooling the flask.

Fig. 71 shows the method of shaking-out the pipe by the use of an electric traveling crane. Two pipes are removed from the flasks in one operation.

Fig. 72 illustrates the hydraulic molding machine, showing the flask attached at the left and the machine with the pattern partly raised before the flask is lowered into position at the right. The sand is rammed in the pipe by the upward move-

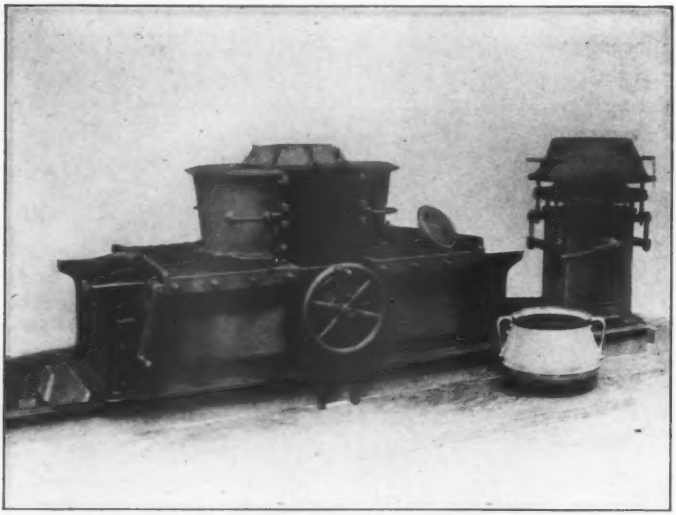

FIG. 74—PATTERN AND FLASKS DRAWN ASIDE

FIG. 75—PATTERN LOWERED INTO FRAME OF MACHINE

ment of the hydraulic ram, which passes through the center of the sand, compressing the sand circumferentially in the flask.

German Machine for Molding Hollow Ware

Figs. 73, 74, 75 and 76 show the method of molding hollow ware on an exceedingly ingenious German molding machine. In Fig. 73 the drag flask and the pattern are under compression

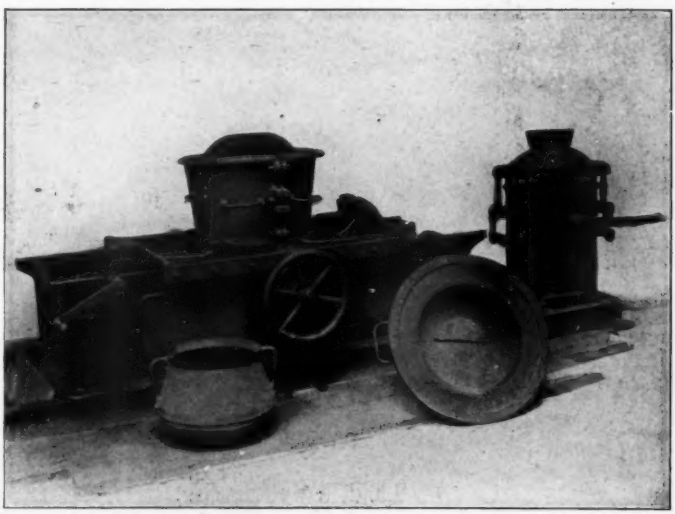

FIG. 76—DRAG HALF OF MOLD ASSEMBLED

for ramming which is accomplished by the lateral compression of the flask against the pattern with the sand between, the green sand core and the drag being made in one operation. The cope stand on which this part of the mold is rammed by hand is shown at the right. The flask is lifted from the pattern by pins operated by the lever.

In Fig. 74 the patterns and the two halves of the flask in which they are embedded are drawn aside.

Fig. 75 shows a further movement of the tables on which the flasks are mounted. The patterns are stripped away

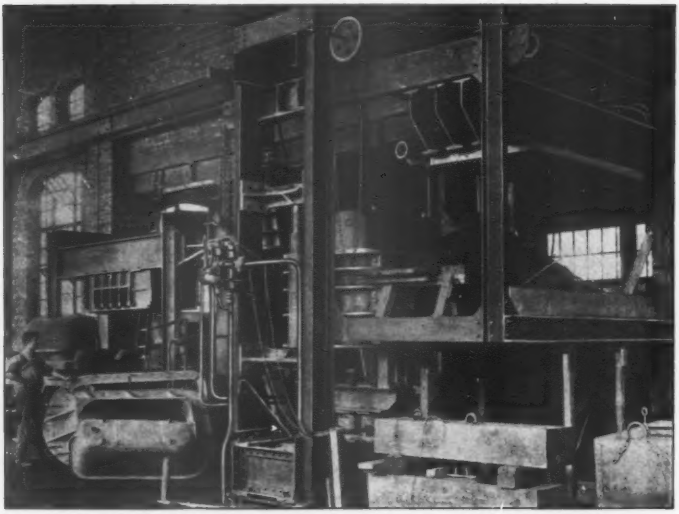

FIG. 77—GERMAN BATH TUB MOLDING MACHINE

FIG. 78—FRENCH MACHINE FOR MOLDING AUTOMOBILE CRANK CASE

from the mold and are lowered through the openings into the frame of the machine. The green sand core is shown mounted on a stool in the center.

Fig. 76 shows the drag assembled, which is accomplished by moving the two halves of the mold, mounted on their respective tables, toward the center. To hold the core in position and to prevent shifting while the mold is being cast, it is slightly flared at the bottom the thickness of the metal and

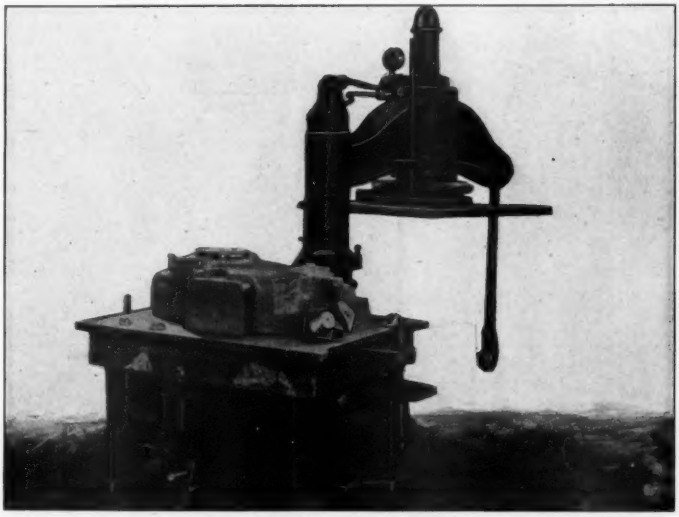

FIG. 79—COPE PATTERN FOR AUTOMOBILE CRANK CASE MOUNTED ON FRENCH MACHINE

at this point, which forms the opening in the casting, it presses against the wall of the drag half of the mold. The core is vented by a wooden cone which is withdrawn after the mold is assembled. The cope half of the pattern is shown in the foregrounnd and one of the cast pots is in front of the machine.

German Bath Tub Machine

The automatic molding machine, Fig. 77, which is of the German type, is exceedingly complicated in design, but for making bath tub molds, for which it is constructed, it neces-

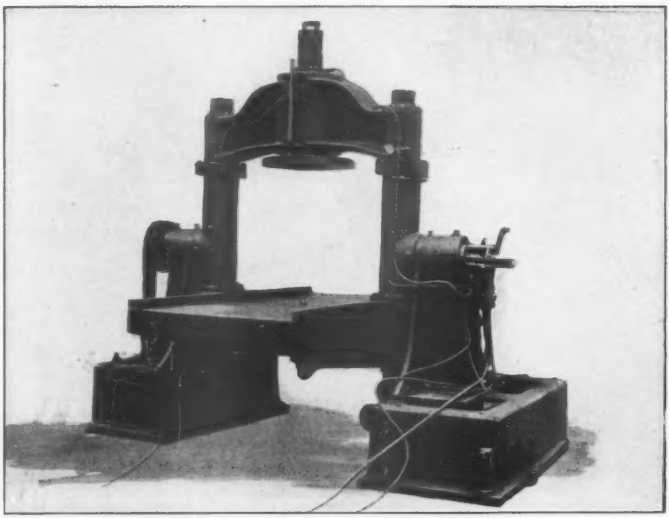

FIG. 80—LARGE FRENCH HYDRAULIC, ROLL-OVER MOLDING MACHINE

FIG. 81—HYDRAULIC MOLDING MACHINE ROLLING-OVER

sarily must have heavy members throughout. On this machine the core, cope and drag are molded and in this view the core has just been made. The tub casting has an over-all length of 6 feet and by the facilities offered by the continuous sand handling plant the output of three men and two boys, including casting and shaking-out, is 18 tubs per day. The machine is hydraulically-operated.

A French type of molding machine on which is mounted a pattern for an automobile crank case is shown in Fig. 78. This machine is of the hydraulic type, with a swinging head, and in this illustration it is rolled over and shows the pattern withdrawn from the drag half of the mold. The pattern is dropped through the plate, which can be clearly seen.

The cope pattern for an automobile crank case, mounted on a French machine, with the loose parts removed, is shown in Fig. 79. The pattern is in position for molding, the head being swung aside to permit of setting the flask in place. The flask is 22 x 30 inches, the drag being 12 inches deep and the cope 10 inches. The aluminum crank case pattern weighs 49 pounds, and varies in thickness from 3/16 to ¼-inch. Notwithstanding this variation in metal thickness, only two chills are required.

A large type of French hydraulic, roll-over molding machine, with the table in position for receiving the flask is illustrated in Fig. 80 and in Fig. 81 the machine is being rolled-over.

In the foregoing discussion of molding machine practice, it was impossible to include all of the various types of molding machines which are rendering excellent service and are effecting economies in casting production. However, practically all of the various principles of molding machine operation have been described and the illustrations, in a measure, indicate the extensive use of this great labor-saving foundry tool.

Discussion—History and Development of the Molding Machine

THE CHAIRMAN, MR. R. A. BULL: — This paper constitutes a most interesting compendium of a lot of very valuable information on molding machine practice, and is one that would be more profitable for future reference and study than for casual discussion. I will be glad, however, to hear any remarks inspired by Mr. Wilson's presentation of the paper.

MR. H. B. SWAN: — I would like to ask if there are any engineers or any gentlemen present who could tell us something about the relative merits of the hydraulic machine and the air machine? Perhaps Mr. Carman might tell us something about that.

MR. E. S. CARMAN: — As to the results obtained, I do not think there would be any difference at all. The reason the hydraulic machines are not more extensively used in this country is that the foundries do not have hydraulic power installations, while European foundries have, and you can readily see that you cannot interest American foundrymen in hydraulic machinery, due to the fact that it would require the installation of a hydraulic power system in addition to the air compressor they already have in their plants. My own opinion is that the air-operated machine is much to be preferred.

Foundations for Jar-Ramming Molding Machines

By E. S. Carman, Cleveland

In order to intelligently consider the proper foundations for modern jar-ramming machines, it is necessary to review briefly some of the machines of earlier types. In many instances it was considered necessary, to effectively jar-ram a

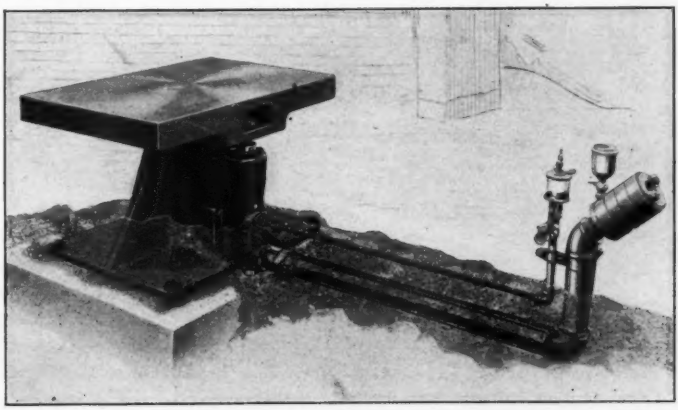

FIG. 1—PLAIN JAR-RAMMING MACHINE WITH ONLY SUFFICIENT FOUNDATION TO HOLD THE MACHINE IN PLACE

mold, to have a machine that would produce a heavy blow. This usually was accomplished by building the machine with a stroke of 3 to 4 or even 6 inches in length. This stroke, of course, would give the heavy blow, as its action was not unlike the blow of a steam hammer.

In order to control the ground vibrations produced by such a machine, it was necessary to provide massive foundations, and in many instances the concrete was capped with several layers of wood to aid in the absorption of the blow.

The recent rapid development of jar-ramming machines has practically reversed the early theory of design, as it has been determined that it is not the force of the machine blow that packs the sand, but that it is packed by the jarring table being suddenly or abruptly brought to rest while the sand in the flask to be packed continues its downward course, thereby producing the pressure which results in the sand packing against the pattern or pattern plate. It is quite evident, there-

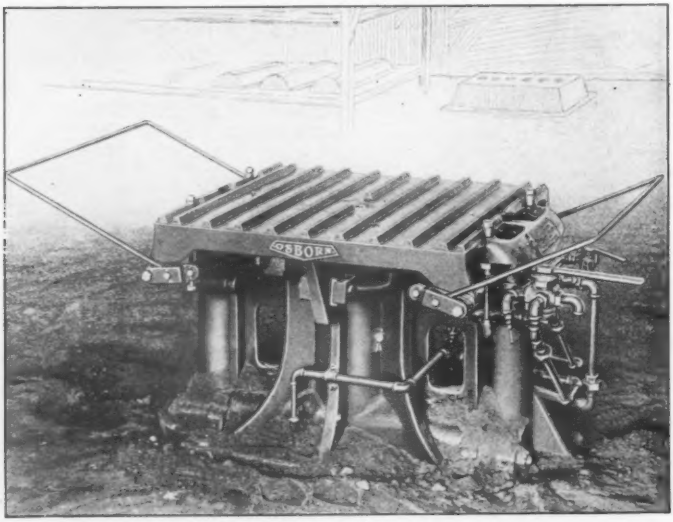

FIG. 2—FOUNDRY FLOOR VIEW OF JAR-RAMMING POWER STRIPPING MACHINE WITH WORKING PARTS PROTECTED

fore, that if the machine which has been brought suddenly to rest be instantly started again on its upward stroke and not allowed to pause, that an increased pressure of the pattern against the sand will result, which causes the sand to lay and not rebound.

A jarring machine necessary to accomplish the foregoing need not be unduly massive in its working parts, nor need it have a long stroke, 1 to 2 inches usually being sufficient. It should have means of controlling the force of the blow of the

table when contacting with the anvil base, as it is evident that the weight of the moving table (or dead load) must not be allowed to freely drop and contact with the anvil block, or it will produce the unnecessary heavy blow. The up-to-date, modern jarring machine prevents this heavy blow by providing

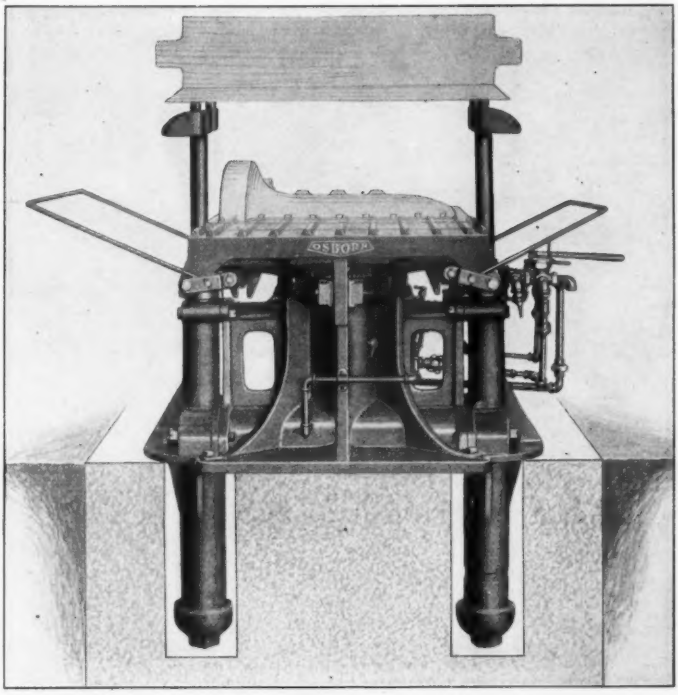

FIG. 3—SAME MACHINE AS FIG. 2, SHOWING SIMPLICITY OF FOUNDATION

an air cushion under the cylinder sufficient to overcome the violent blow caused by the dead load, allowing only sufficient blow to cause the instant reversal of stroke.

A machine that accomplishes the foregoing not only will ram a good mold in a very short time, but will do so without excessive or detrimental vibration in either the machine, pattern or foundation.

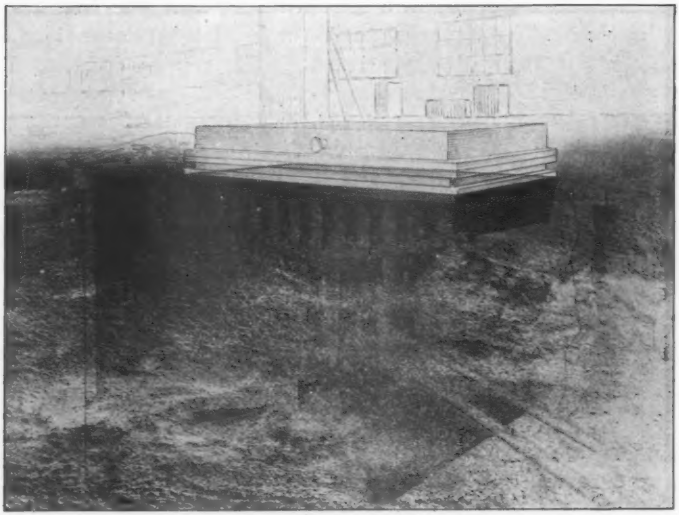

FIG. 4—A LARGE, 42 x 97-INCH, JAR-RAMMING MACHINE, SHOWING THE BASE AND FOUNDATION IN PHANTOM

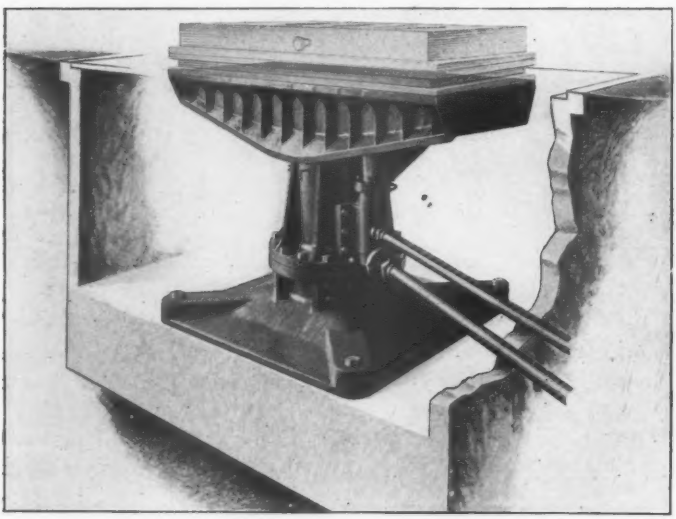

FIG. 5—SAME MACHINE AS FIG. 4, SHOWING SECTION THROUGH FOUNDATION AND PIT

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As we now approach our subject—the machine foundation—it is evident that with such a machine the extremely massive foundation is not essential and, therefore, our consideration will be from the standpoint of economy and accessibility.

Of first importance is the kind and nature of the soil upon which the machine foundation is to be placed. A dry gravel is considered the next best thing to solid rock and will safely

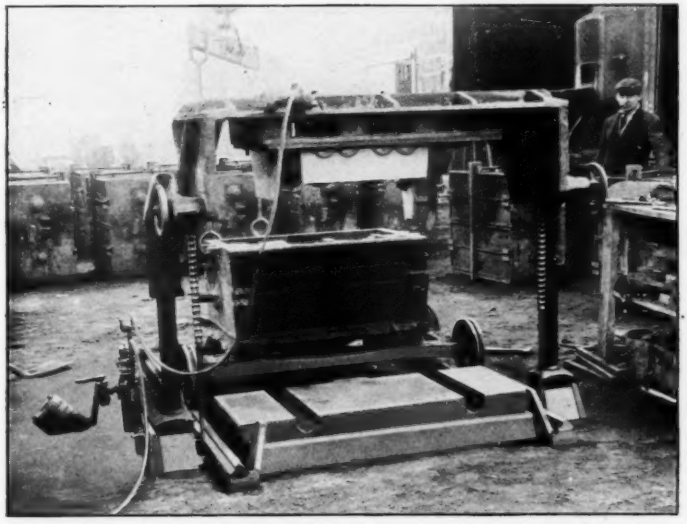

FIG. 6—FOUNDRY FLOOR VIEW OF 54-INCH DIRECT-DRAW ROLL-OVER JOLT MACHINE

stand a load of 6,000 to 8,000 pounds per square foot. Dry sand or dry sand and gravel mixed makes a very good foundation base and will withstand a load of 4,000 to 8,000 pounds per square foot. Clay soils vary widely; a soft clay will flow in all directions under very light load, and should not be loaded more than 3,000 pounds per square foot, while a dry clay will satisfactorily stand a load of 3,000 to 5,000 pounds per square foot. If the foundation is to be placed on *made* ground or *fill*, provision should be made to keep the ground perfectly dry and

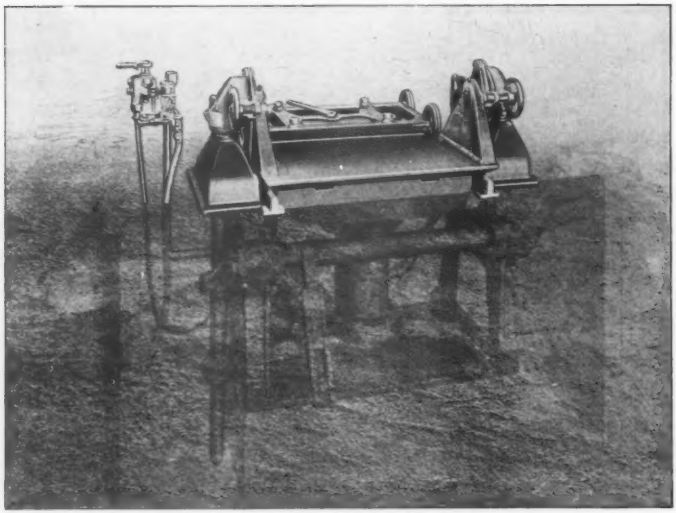

FIG. 7—SAME MACHINE AS FIG. 6, WITH BASE AND FOUNDATION IN PHANTOM

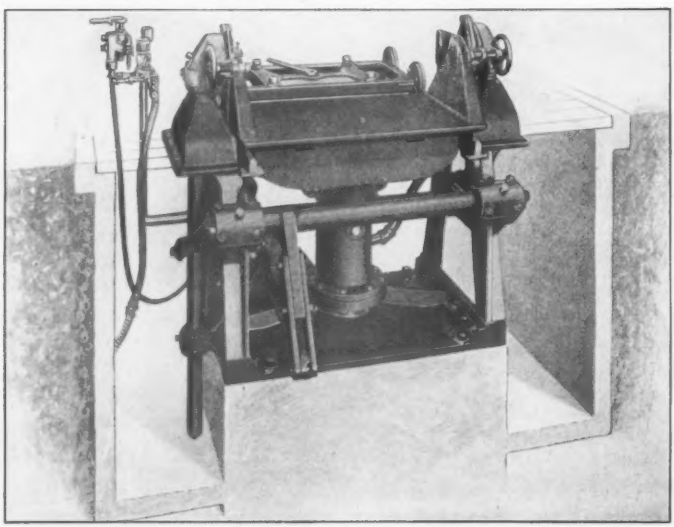

FIG. 8—SAME MACHINE AS FIG. 6, SHOWING SECTION THROUGH FOUNDATION

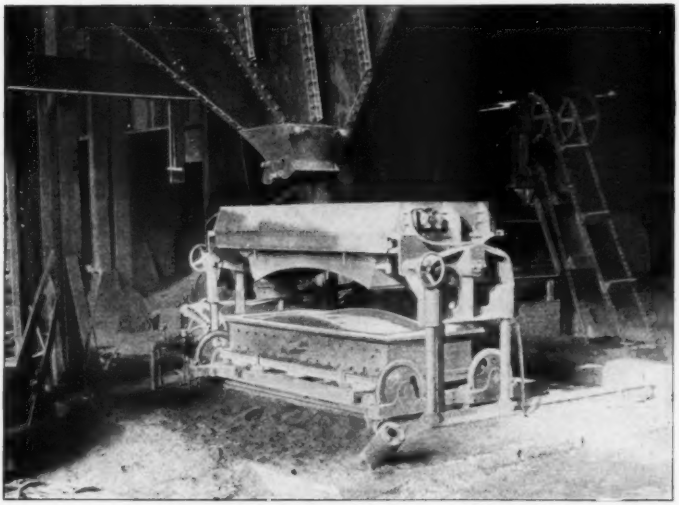

FIG. 9—VIEW OF LARGE, 36 x 150-INCH DIRECT-DRAW ROLL-OVER JOLT MACHINE

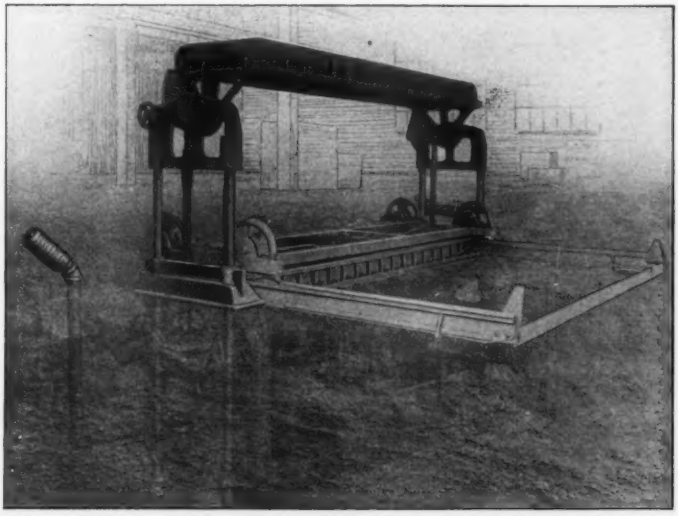

FIG. 10—SAME MACHINE AS FIG. 9, BASE AND FOUNDATION SHOWN IN PHANTOM

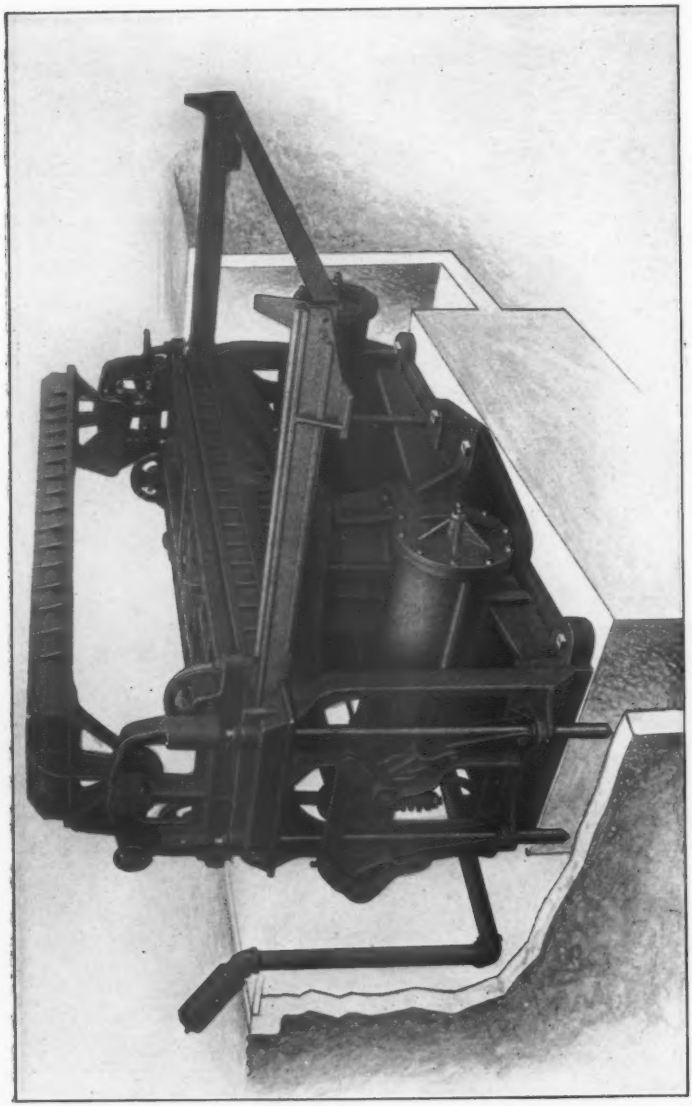

FIG. 11—SAME MACHINE AS FIG. 9, SHOWING SECTION THROUGH FOUNDATION

free from water. With this condition existing a satisfactory foundation can be made, such condition being more desirable than a wet or oozey clay soil. When the foundation is placed on *clay* or *fill* better results can be obtained by making the foundations cover a larger area rather than making it of

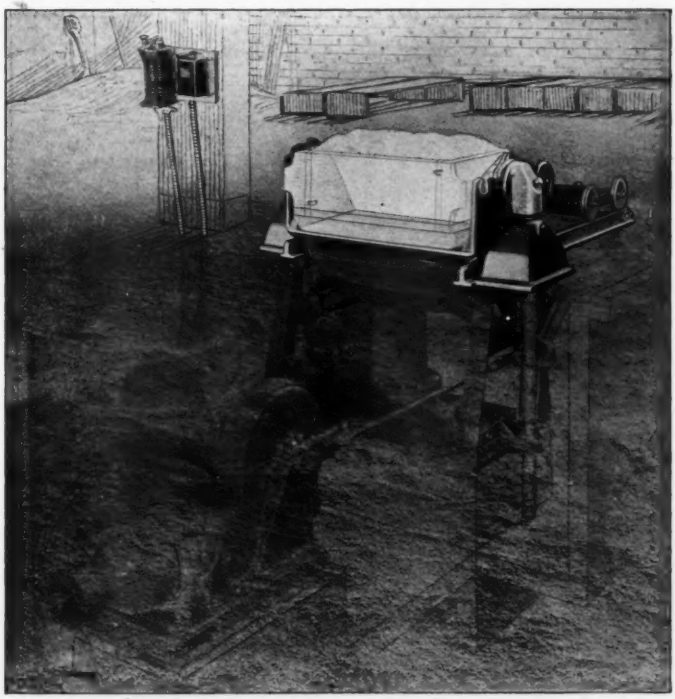

FIG. 12—FOUNDRY FLOOR VIEW OF 42-INCH ELECTRICALLY-OPERATED DIRECT-DRAW ROLL-OVER JOLT MACHINE, SHOWING FOUNDATION IN PHANTOM

greater depth, unless the fill is of such depth that the foundation may be extended through to solid soil.

It must be remembered that when we place a molding machine in the foundry that we are actually violating the old established principle of machine installation and *placing it in a sand pile* instead of an engine room, or other dirt and dust-

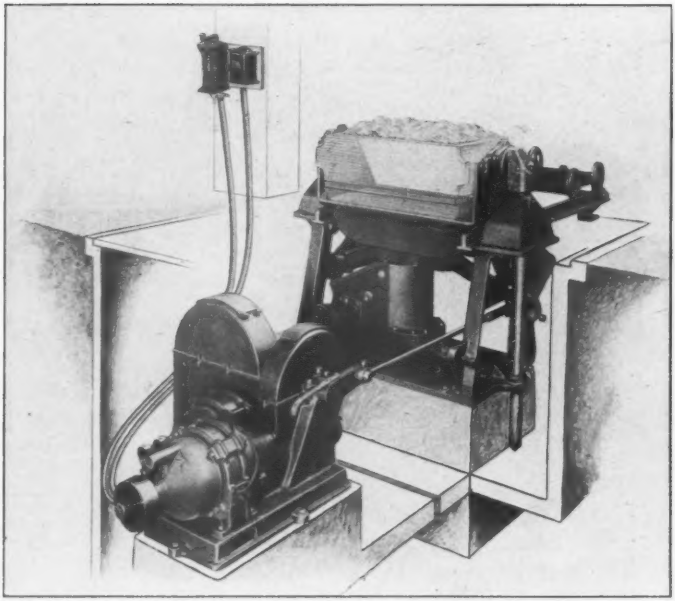

FIG. 13—SAME MACHINE AS FIG. 12, SHOWING SECTION OF FOUNDATION

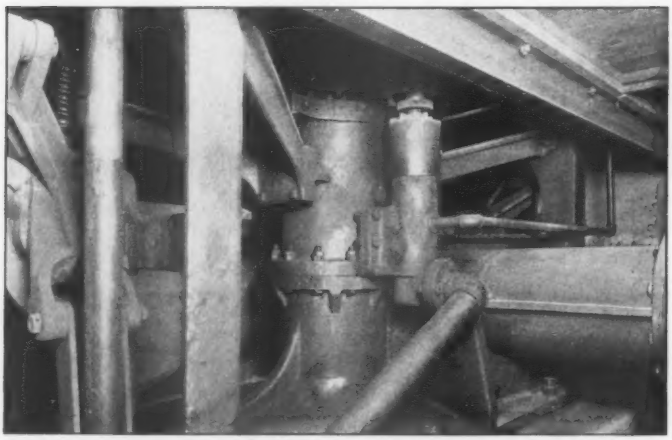

FIG. 14—THIS SHOWS THE EXCELLENT CONDITION OF THE BASE OF THIS JAR-RAMMING MOLDING MACHINE AND ITS FREEDOM FROM SAND, ETC.

FIG. 15—ENTRANCE INTO THE FOUNDATION PIT FROM A BASEMENT ROOM

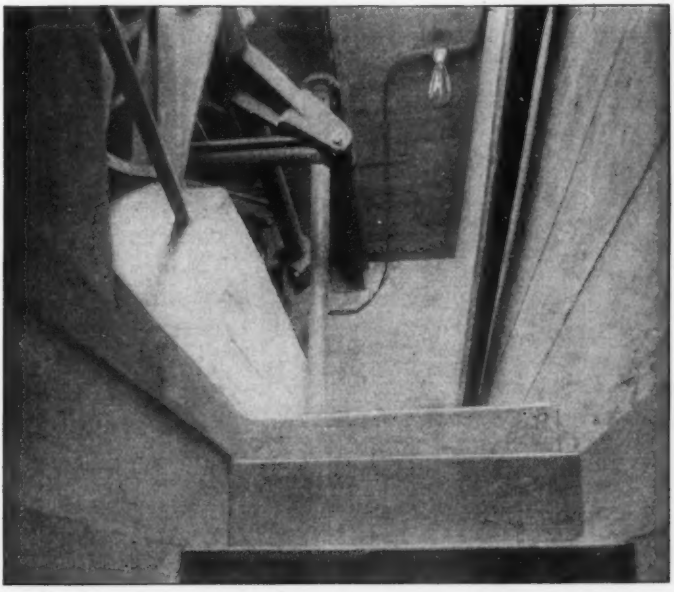

FIG. 16—ENTRANCE-WAY, SHOWING STEPS LEADING INTO THE PIT

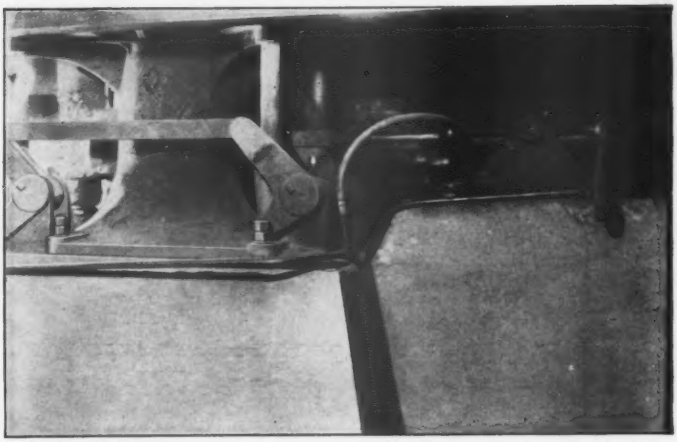

FIG. 17—JAR-RAMMING MOLDING MACHINE SET ON A PIER

FIG. 18—JAR-RAMMING MOLDING MACHINE FOUNDATIONS AT THE PLANT OF THE CENTRAL FOUNDRY CO., HOLT, ALA.

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proof room, and yet notwithstanding this extraordinary condition, and without giving the machine proper care, many foundrymen expect as good results from the machine in the sand pile as they do from the machine that was placed in a dust-proof room and in charge of an expert mechanic.

The accompanying illustrations will demonstrate that it is economy to provide a foundation and setting that will give ample protection to the machine, by making it impossible for sand to collect on the machine or its moving parts. They also will show the advisability of providing ample space around the machine so that the mechanic can easily oil, inspect and keep the working parts in order, the same as he does the machine that was placed in the engine room. The depth of the space surrounding the machine should be sufficient for a man to stand erect, suitable lighting facilities should be provided and a stairway or ladder should lead into the pit.

The covering of the pit or foundry floor should be made of 2-inch matched planking and should be fitted tight against the machine. The trap door leading into the pit should be hinged and of ample size.

Illustrations

Fig. 1 shows a simple, plain jarring machine of such size as not to require a pit, the foundation being only sufficient to hold the machine in place. The design of the machine permits the sand to be filled around the base, as all working parts are protected from the sand and grit.

Fig. 2 is a foundry floor view of jar-ram power strip machine, having working parts protected.

Fig. 3 is the same machine as Fig. 2, showing the simplicity of the foundation.

Fig. 4 is a foundry floor view of a large 42 x 97-inch plain jar-ramming machine, showing the base and foundation in phantom.

Fig. 5 is the same machine as Fig. 4, showing section through foundation and pit.

Fig. 6 is a foundry floor view of 54-inch direct-draw roll-over jolt molding machine.

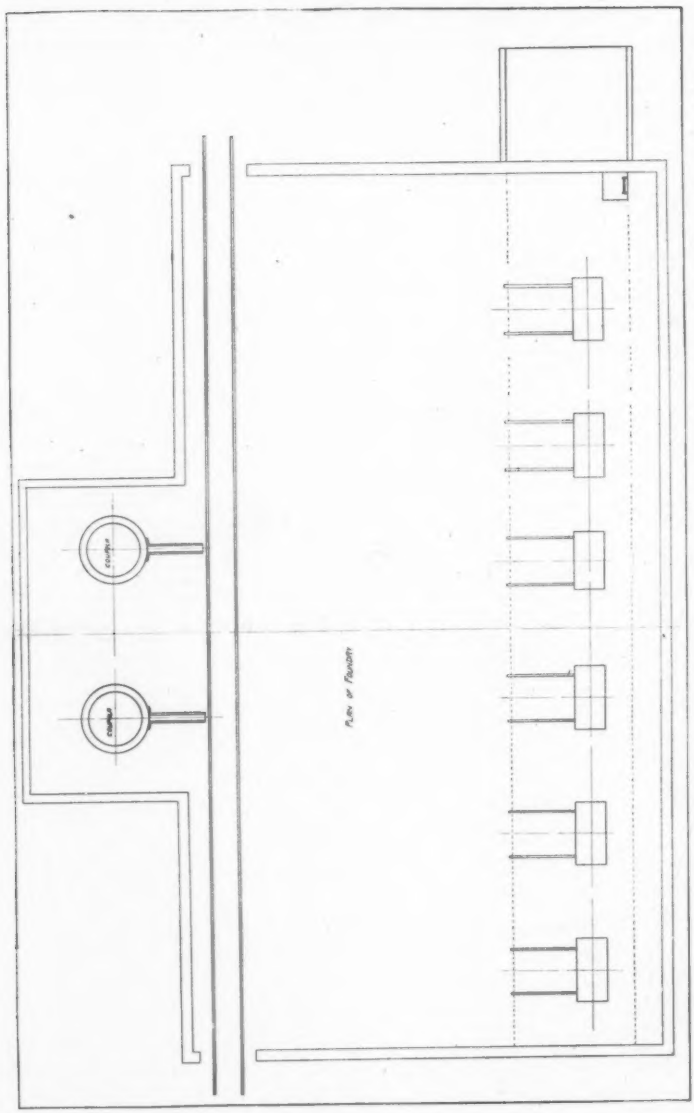

FIG. 19—PLAN VIEW OF A PROPOSED FOUNDRY HAVING A TUNNEL OR BASEMENT FOR SETTING MACHINES

Fig. 7 is the same machine as the one illustrated in Fig. 6, showing the foundry floor view with the base and foundation in phantom.

Fig. 8 is the same machine as Fig. 6, showing a section through the foundation.

Fig. 9 is a foundry floor view of a large 36 x 150-inch, direct-draw roll-over jolt molding machine.

Fig. 10 is the same machine as Fig. 9, the base and foundation being shown in phantom.

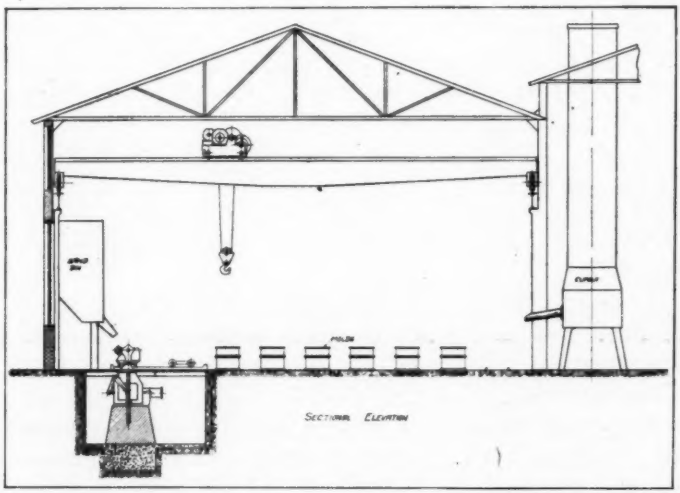

FIG. 20—CROSS-SECTION OF THE PROPOSED FOUNDRY

Fig. 11 is the same machine as Fig. 9, showing a section through the foundation.

The foundations shown in Figs. 8 and 11 illustrate clearly the necessity for providing suitable space around the machine, and also the advantage to be gained by placing the machine base on a pier, thereby making it possible to keep the machine free from sand or dust accumulation.

Fig. 12 is a foundry floor view of a 42-inch electrically-operated, direct-draw roll-over jolt-molding machine with base

and foundation shown in phantom. Note the position and simplicity of controllers.

Fig. 13 is the same machine as Fig. 12, showing section of the foundation and illustrating clearly the provision made for the motor base. Note that the foundation of the machine and of the motor base are cast separate, thus preventing the vibrations from reaching the motor.

This fully electrically-operated, jolt-ram, roll-over, pattern draw machine is distinctly a new type, all movements being rapid and positive and the control is such as not to require a skillful operator.

Figs. 14, 15 and 16 are views taken at the new steel foundry of the Otis Elevator Co., Buffalo. These show the same style of machine as illustrated in Fig. 9.

Fig. 14 shows the excellent condition of the machine and its freedom from sand, etc. Fig. 15 illustrates the entrance into the foundation pit from a basement room adjoining, while Fig. 16 is a view taken at the entrance-way, showing steps leading into the pit.

Fig. 17 is a view taken at the plant of the American Steel Foundries, Alliance, O., showing the advantage to be gained by setting the machine on a pier. Note the freedom from dirt and dust.

Fig. 18 is a view taken at the plant of the Central Foundry Co., Holt, Ala., showing the most approved manner of providing foundations. The cylinders of the machines extend through the ceiling of this basement leaving only the jolt table exposed on the molding floor above. Seven machines are in this row, all of which are readily accessible.

The engineer or architect called upon to design and build the foundry of tomorrow will do well to thoroughly consider the best method of installing and maintaining the molding machines to be used, placing them in such manner as to insure ample protection from dust and grit, making it easy to give the machines the care and attention they deserve.

The author's idea of a foundry that will best meet these requirements is set forth in Figs. 19 and 20. These illustra-

tions show the plan and cross-section of a proposed foundry, having a tunnel or basement extending the full length of the molding floor. The floor of this tunnel or basement should be at least 7 feet below the ceiling and the width should be sufficient to allow a clear passageway on one side of the machines; the piers for the machine foundations can be placed at any time and to suit any condition.

Discussion

THE CHAIRMAN, MR. R. A. BULL: — The matter of foundations for jar-ramming molding machines is one of great concern to foundrymen, particularly where they have trouble with quick-sand. I would be very glad to have some discussion of this topic.

MR. S. D. SLEETH:—I think more stress should be laid on the subject of foundations. I have been in some foundries where they had molding machines and you would be within five feet of them and there was no jar, and twenty feet away from them the jar would shake down a mold; in fact, one could not put anything on the floor that was not liable to fall out, within maybe fifteen feet of the machine; the vibration appeared to carry through the ground so far, not right directly at the machine, but when one got a certain distance away. I think more stress should be laid on that. We had to go twelve feet to get down to gravel to get a solid foundation, so there would be no jar.

MR. E. S. CARMAN: — I expected that point to come up. I just want to again emphasize the point that I brought out in the beginning of this paper, and that was that foundation shocks are due altogether to the kind of blow that one gives the machine. If you are going to use the machine as you do a steam hammer, you are sure to have foundation shocks; but my experience with a molding machine is that you do not require that kind of a blow, because, after all, it is not the blow of the

machine that packs the sand; it depends altogether upon the depth and weight of the sand, and therefore, my idea regarding the overcoming of foundation shock is that you should do away with the cause; you should eliminate them by cushioning your falling table to such an extent as to practically overcome the foundation shocks. An examination was made after nine months of service, of a 15-inch center strike machine that had been making molds weighing 1,000 or 1,500 pounds, and it was found that the center pin, which was 3½ inches in diameter and chamfered 1/64-inch on the bottom or contact point, had only brightened the striking block or anvil to the size of a dollar; I have seen the same style machines after years of service that the center pin had not made an impression into the cast iron anvil of more than 1/64-inch; does this not show that there was very little shock reaching to the foundation?

Patternmaking for Molding Machine Work

By E. I. Chase, Detroit

There are several points of interest connected with making patterns for machine molding which are of no little importance to the foundryman. Without correctly-made patterns, properly plated, the machine operator cannot reach a maximum output.

First, where a shop has an appreciable number and assortment of machines, it must be decided which type of machine is best adapted to the job in hand. In doing this it is well to consider from the design of the part, the number of castings to be produced, the cost and what material is best suited for the patterns. Split wood patterns made for ordinary molding are disappointing in results when put on plates, because of their liability to bruise or chip off in the process of peening. Wherever possible, a cast iron pattern should be given first choice, but it has one drawback in not taking the solder well. A considerable amount of soldering is sometimes necessary, especially where the pattern is subject to numerous alterations and retouching after it is finished.

Brass Patterns

Second, consideration should be given to brass patterns; they are desirable, but wear faster and are more easily marred and dented than those made of iron. White metal patterns are in demand for rush jobs and a limited production; they are easily filed, soldered and fitted. For patterns of good weight and size they tie up considerable money. They are softer than brass and wear faster. The best thing that can be said of aluminum patterns is that they are light, and especially for very large jobs such as automobile engine bases, this property has great advantages. As a pattern material, however, it has several faults. Aluminum is hard to solder, has a high and inconsistent shrinkage, is soft and no aluminum solder will

hold pieces on patterns when used for any length of time on jar-ramming machines or where a vibrator is used. I have made aluminum pattern plates with the patterns cast integral with the plate, but have found them disappointing. After some little experimenting along this line, we rammed the pattern castings in a tightly pinned wooden flask, separating the cope and drag with a ⅜-inch planed iron plate, having the outline of the pattern plate cut out. This was used to chill the outside, and the profile of the cut-out was made with a five-degree bevel to permit the aluminum cast plate to be extracted easily and without bending. Before closing the mold, the parting was carefully thumbed to make a fillet where the pattern joined the plate, to prevent shrinkage and consequent undercut. In spite of this care, however, the plates were unsatisfactory, principally because the center was thinner than the outer margin, notwithstanding the use of risers to feed it. The resulting plates might do where a variation in casting thickness could be overlooked, but as both cope and drag, rammed from these plates, had a convex surface of from 1/64 to 1/32-inch, the mold would be liable to crush and distort the castings. It is only fair to state, however, that many shops, especially stove foundries, have solved many of the difficulties of making these plates and use them extensively. It is possible that the trouble encountered by us was due to making the plates too thick. Of course, the patterns must be made suitable for the work for which they are intended and the machines on which they are to be mounted, and in the case of a straight parting line, this is easily accomplished.

Three-Part Mold or Cover Core

Another point to be considered is whether, when the design of the pattern requires two partings, it is better to make it a cope, cheek and drag job, or to use a cover core instead. The employment of cover cores is less expensive, and they insure a greater output of molds. Deciding this point is a matter of experience and judgment, and the policy of the foundry for which the pattern is made also is a controlling factor. Where loose bosses or brackets are to be taken care of, cores either must be provided to cover them, or, where

possible, they should be used as drawbacks to be withdrawn from the sand into the pattern after ramming is finished. This can be accomplished by suitable levers or screws located underneath the pattern plate, and connected inside of the pattern by slides or cams, with sufficient throw to draw them clear of the mold. These drawback pieces must fit practically sand-tight but loose enough not to jam as a result of ramming. It is possible, where there is sufficient inside pattern room, to fit three or four drawbacks to one cam located parallel to the pattern plate, so that by one motion of the lever or screw, they may be drawn in simultaneously. It might be well to state that these loose pieces should be withdrawn after all rapping on the plate is completed and when the pattern plate is to be raised from the flask.

Frequently, a boss projecting from the pattern may be cared for by leaving it loose and fastening it to the pattern, either with wires loosely fitted to holes drilled in the boss, or preferably by attaching it to the pattern with dovetails. Where dovetails are used, they should have a good taper lengthwise, so as to leave the pattern easily as it is drawn from the flask. The fastening of bosses to the pattern by loose wires is not to be recommended on account of the liability to ram out of position after the wires are withdrawn; sometimes they may be used for a limited output of castings. Any method of holding bosses which is not positive is liable to be unsatisfactory. The more mechanical the method, the more foolproof it is.

Irregular Partings

Some patterns must be made with an irregular parting, which will necessitate pockets of green sand in the drag or cope. In such a case it is desirable to give the sides of these pockets all the draft possible, not less than 30-degrees, though more is preferable, on account of the liability to shave or crush the sand when closing-on the cope. Besides giving good draft to these pockets, they should have all the spread possible, as the narrow pocket is more liable to drop than one given more width. Large draft on pockets is essential on patterns used on jolt machines, as it tends to prevent the cracking of sand which happens when the sides of the pocke:

form a more acute angle. Also, sharp edges should be avoided, and the patternmaker can save considerable after-work by watching where to make round corners and fillets. In Fig. 1, the pocket of sand at *X* is more liable to drop or crush outwardly into the mold, than the one at *Y*.

A good way to take care of these pockets is by screwing pads to the plate under the projecting parts of the pattern and giving these pads all the draft and spread possible; then, after removing this half of the pattern and securing the cope and drag plates together, babbitt metal can be poured through holes drilled in the bottom of the corresponding plate. If this is well done and the plates have been previously heated, the shrinkage of the babbitt does not affect the parting line of sand in the drag and cope. This is a cheap, quick, and the best

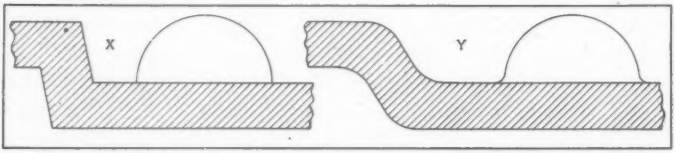

FIG. 1—HOW TO PROVIDE FOR POCKETS OF SAND. THE WRONG WAY IS SHOWN AT *X*, BUT A BETTER WAY IS ILLUSTRATED AT *Y*

method of accomplishing the fitting of cope and drag plates, as the pad can be easily worked on and the corresponding pocket is automatically fitted by the melted babbitt. Plates fitted in this manner have given a production of 15,000 to 20,000 castings without showing appreciable wear.

Before pouring the babbitt, plenty of anchor holes must be drilled in the plate to secure the babbitt and to prevent it from loosening by vibration or jar-ramming. Again, some patterns require an irregularly-planed plate, for instance, a gas engine manifold with an angular outlet extending some distance beyond the plane of parting. Consequently, a flask specially made for the pattern is required, which is of no use for any other job. The cope and drag pattern plates must match each other perfectly and also the flasks. This kind of

a job is expensive to fit up and is used only for a large output of a special casting. In connection with a pattern of this kind there usually is a crooked core box to match, which will need accurate core driers in order to keep the thickness of metal in the casting of uniform measurement. In specific cases, such as gas engine manifolds, we have found it necessary to use chaplets in both drag and cope to keep the core in position, and to put chaplet bosses on the pattern sufficiently large to burn to the chaplet. When the design of the casting permits, it is sometimes better to put the chaplet boss in the core, which does away with the operation of grinding it from the rough casting. Enough metal in the boss must be allowed to make the casting air-tight. We have drilled holes to the proper depth through bosses and have rammed the chaplets in position on the pattern. Also, we rammed small, round steel punchings, about 5/16-inch in diameter in the cores where the chaplets bear. Where the chaplet stems are small and no metal bearings are used for them in the core, it is not uncommon to find, that from the pressure of the metal and the softening of the core, the chaplet has penetrated the core and has permitted it to be misplaced.

Plating Patterns

With reference to plating patterns for different types of molding machines, we must consider the size, shape and depth of pattern when deciding what type of machine to use. A deep pattern will necessitate a deep draw and would go well on the roll-over or stripping plate type of machine, or modifications of these; a choice will depend upon the shop for which the pattern is to be made. Again, heavy patterns need a power machine. For small squeezers using flasks about 12 x 18 inches, the pattern can be put on a rolled steel plate, preferably not less than ¼-inch thick, to avoid springing in ramming, but we find it better to use a ⅜-inch aluminum plate, cut from rolled stock, to avoid planing, on account of the tendency of steel to rust and flake off, unless well looked after, especially where the plates are stored for a considerable period between orders. These plates must be carefully drilled with a

jig to insure fitting the flasks and the use of renewable hardened steel bushings is recommended. These are inserted in pattern plates to prevent undue wear and to preserve uniformity with original drilling when new bushings become necessary. Jigs for drilling flasks should not merely be a frame containing holes, but should be a finished piece of work worthy of the art of the toolmaker. Attention should be directed to the need of rigid exactness in drilling the flasks which should have the same hardened bushings, previously mentioned, and the wear on the flask pins should be watched. Several points should be noted to prevent poor castings; one is to have the pattern fit the plate tight without leaving an uneven parting which will result in broken edges of sand and a consequent ridge on the parting line on the casting; another is to have the fit of the core to the print exact, as a little crush will squeeze loose sand into the mold, resulting in a dirty casting. Gages used after setting the core, often show any misplacement of the core which would result in a thin shell in parts of the casting.

Mounting Small Patterns

When small patterns are mounted on these plates, they usually are located on both sides, for cope and drag, but in a great many cases where no cores are to be set, which would have to hang in the cope, half the pattern cost can be saved by putting both cope and drag halves of the pattern on one side of the plate. Patterns on one side of the plate are especially suitable for jar-ramming machines. This practice is not recommended, however, where there are a large number of small patterns in a flask, on account of the liability to ram away, and also, a very small shift looks unusually large on a small casting. If the pattern plate and the flasks do not have hardened steel bushings, a small shift can easily be doubled in size. This method requires the accurate laying-out of the patterns on the plate and special gating, since whatever is rammed in the drag appears also in the cope. Occasionally a gate is laid loose on the plate while ramming the drag and is removed while ramming the cope. However, this is not good practice, as there is always loose sand left where the gate joins the casting. In looking over sample castings from patterns mounted on one

XUM

side of a plate, care should be exercised in condemning the pattern for shifts, *especially* on small pieces with a considerable number in a flask. Any shift showing on one side of the center line of the flask in the drag side of the casting will show correspondingly on the other side in the cope, and it is sometimes puzzling to determine the cause when shifts show otherwise. These shifts may be attributed to several causes such as ramming-away, weak flasks, loose flask pins, or sagging caused by too soft ramming when the cope is set on edge for blowing out the sprue, and in snap flask work, by carelessness in putting on jackets.

In Fig. 2, at *A*, it would seem that the patterns were not mounted properly in relation to the center line and the difficulty

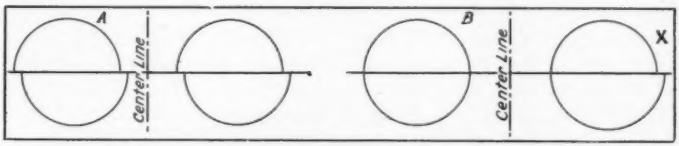

FIG. 2—THE RESULTS OF SHIFTS IN PLATED WORK. IT WOULD SEEM THAT THE PATTERNS AT *A* WERE NOT PROPERLY MOUNTED IN RELATION TO THE CENTER LINE AND THE DIFFICULTY IN *B* APPEARS TO HAVE BEEN CAUSED BY RAMMING AWAY AT *X*

at *B* appears to have been caused by ramming-away at *X*. This indicates that the patternmaker should allow all the draft possible on plated patterns, and should avoid sharp corners especially where core prints and pattern meet.

In the latter instance I recommend a fillet in most cases as it is more desirable to grind off a slight fin than to have a core crush in the mold, and thus get a dirty casting. Where patterns are put on one side of the plate for both cope and drag, they may be laid out by templates, by center lines and by paper. Where there are only one or two patterns in a flask, I prefer working by center lines, although templates may be used. The most commonly used template is a metal plate about ⅛-inch thick, drilled to match dowel pin holes in the drag halves of patterns and reversed on flask pins to drill the other side of the center line of the plate for the cope halves.

When putting a large number of patterns on a plate, the cheapest and quickest way is by means of paper. The paper should be suitable for the work and very good results are obtained with gasket paper, about 0.015-inch thick. This method consists in plating one-half of the patterns on one side of the center line and then removing the patterns and replating them with the paper underneath. With a sharp, pointed knife, cut carefully around the patterns and reverse on the flask pins and the other halves of the patterns will fit in the outlines while the screw holes are marked and prick-punched. Exercising care in cutting the paper and drilling the plates, accurate work will result. When the patterns have been screwed to the plate it is well to drill through both patterns and plate for close fitting dowel pins, to prevent shifting. The patterns, in all cases, must be securely fastened to the plate, preferably by screws, as rivets will work loose. When we consider large patterns that are heavy enough to necessitate the use of roll-over machines, we usually mount cope and drag on separate plates using two machines side by side. In some instances, where the output, as in a case of this kind, is large, we use a battery of machines making the same casting. It is advisable to put a distinguishing mark on each pattern for identification purposes. A specific example of this is a group of six gas engine cylinder drags served by three cope patterns with three sets of core boxes interchangeable for all patterns. In plating these patterns we found it advisable to use templates to insure the matching of the cope and drag plates. In this instance it was necessary to put distinguishing marks not only on the cope and drag patterns, but also in the several core boxes. It will be found good practice to make the core fit the drag pattern accurately in length, and to make the cope prints from 1/16 to ⅛-inch longer, to prevent shaving when closing the mold. When using a jar or jolt-ramming machine, it is advisable to fasten the pattern securely to prevent loosening and consequent poor work.

Plating Patterns for Stripping Plate Machines

Regarding stripping plate machines, all probably are familiar with the method of plating patterns and making a

babbitt margin all around the pattern. These machines are principally used for gears and similar special castings where very little fin is allowable on account of the undesirability of grinding it off. The three-part flask is not generally used in connection with molding machine practice. It can be employed equally as well as the plain two-part flask, but the cheek must be drilled perfectly in line on the drag and cope side, and this can best be accomplished by drilling all holes at one setting in a specially designed jig. The cope, cheek and drag *must* be planed, or ground, to fit, as otherwise poor work will result. Often in three-part flask work, only one machine is necessary, as both cope and drag may be shallow enough to be rammed on dummy plates and lifted off without rolling over. Sometimes we can avoid using a three-part flask by placing a cover core over the part not possible to draw with the pattern, and if cores are to be set extending below the cheek, a much better core seat is made than with green sand.

Mounting Large Core Boxes

The points about draft, fillets and avoiding sharp corners are applicable to the core box as well as to the pattern and we find it profitable to mount the large core boxes on rock-over machines to insure both speed and accuracy. In a foundry where several different makes and sizes of machines are used, it is advisable, when practicable, to make the pattern plates to fit two or more machines. This will permit continuing work in case of breakdown or of being obliged to give up a certain machine for a special job and will make a greater number of machines available for each job.

Most squeezers are suitable for patterns mounted on either one or both sides of plates, while several small jar-ramming and power squeeze machines can only be used with patterns on one side of the plate. When we come to consider large rock-over or roll-over machines, we usually must mount cope and drag on separate plates, and as previously stated, we must try to arrange their use on several different styles or sizes. In the above statement I should have included the designing of plates to fit two or more types of machines where possible, as well as more than one size of the same type. We have

some plates fitted for squeezers, two sizes of rock-over machines and one roll-over machine, so in most cases we can use them on whichever machine is vacant.

In conclusion, I consider the main points to be watched in plating patterns for use with molding machines are accuracy, draft, and fillets.

Dynamic Properties of Steel Employed in the Manufacture of Castings of Various Types

By J. Lloyd Uhler, Pittsburgh

The recognized importance of knowing something more than the static properties of steel employed in the manufacture of castings for various uses, such as locomotives, turbines, electric cranes, etc., led some of the steel foundrymen to make a thorough study of their product in recent years. It is just as essential to know the probable behavior of steel in service, which is subjected to shock or alternating stresses, as it is to know the static properties of the steel used. Too much reliance generally is placed upon the limited information furnished by the static tension test, with the result that numerous failures in practice are often inexplicable, and for that reason experiments were begun to look for some other device which, in a commercial manner, would divulge something concerning the other properties of the castings.

It has been long understood that materials are liable to degenerate in quality at a rate depending upon the service which they undergo. The numerous every-day failures which cannot be accounted for, are forcing the metallurgical investigators to make research and investigations into the action on steel exerted by complicated forces and they realize the fact that resistance to fatigue is not entirely a function of static strength.

Original Vibrating Machine Used

In 1907 the manufacture of vanadium steel castings was started on a small scale and one of the claims for this alloy was resistance to fatigue. This claim was investigated to determine whether it could be substantiated, and in July, 1907, test bars of carbon and vanadium steels were prepared, which were tested, by courtesy of the Pennsylvania Railroad Co., at Altoona, Pa., on an improvised vibratory machine which was used for making tests of staybolt iron. This machine was

an old slotter that had been equipped for making vibratory tests and was provided with a registering device which gave a complete record of the number of alternating stresses. The bar was fastened rigidly in a vise and extended out to the slotter arm, 8 inches distant. It had a plate fastened to the arm with a hole through it so that the free end of the test bar, which was supplied with a round nut, could be placed in it with an allowance of ¼-inch play, thereby allowing the test bar to be deflected ⅛-inch each side of the neutral position. This

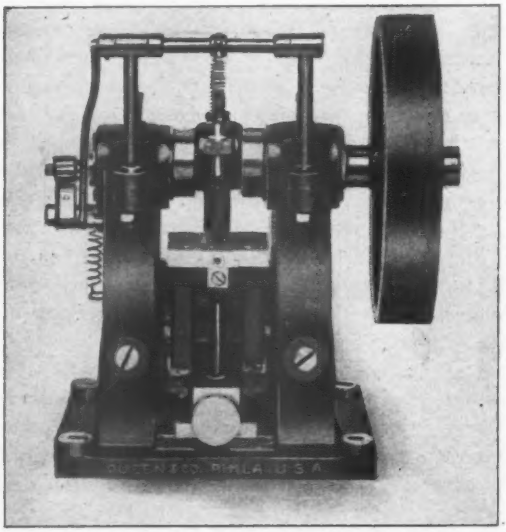

FIG. 1—TURNER & LANDGRAFF TESTING MACHINE

machine gave only 30 vibrations per minute. The size of the bar was ⅝-inch round and 15 inches long.

The Turner and Landgraff testing machine was next employed by investigators. This is the new modification of Wohler's method of dynamic testing, which was introduced in 1905 by Prof. Arnold, of Sheffield, Eng. In making this test the piece is held securely in a vise at one end and is moved backwards and forwards by a slotted arm which communicates

to the piece successive permanent distortions in each direction, produced by impact and followed immediately by a pushing motion. As a result, the test piece is fractured finally on the line of the vise at which point the most severe stresses are created. The slotted arm moves on a crank, so that the pushing motion is performed without the interfering factor of *rub* as the slotted arm describes the same arc as the distorted test piece. The design of the machine is shown in Fig. 1.

Wohler Endurance Testing Machine

The next series of tests were made on the Wohler dynamic or endurance testing machine. It subjects a specimen to a reversal of bending stresses on a rapidly rotating bar, but this

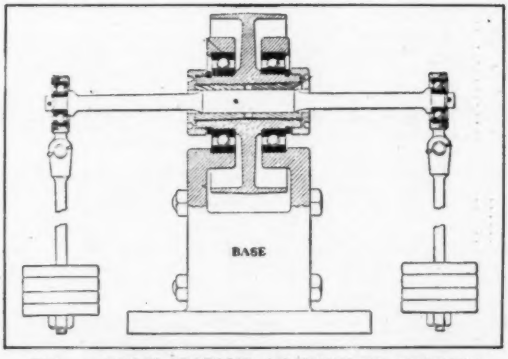

FIG. 2—CROSS-SECTION OF WOHLER TESTING MACHINE, ALSO KNOWN AS THE SOUTHER TYPE

form of testing often gives widely varying results, even from the same bar and does not necessarily detect dynamically weak steel. This is known in this country as the Souther test. Prof. Arnold's original idea in devising this test was to introduce the Wohler method to pratical use by reducing the time needed to make this test, namely from days and hours, to minutes. His argument was, that instead of making the test within the elastic limit, but which always was made just beyond it, the result would quickly reflect the liability to fracture within the elastic limit, under stresses applied for a long period. But it was found that the test predicted liability to fracture from causes

Dynamic and Static Results Obtained on

Castings made from steel containing.....0.20 to 0.25, 0.25 to 0.30, 0.33 to 0.40 and 0.40 to 0.50 per cent carbon
Castings made from vanadium steel containing.....0.23 to 0.28, 0.38, 0.47 and 0.49 per cent carbon
Castings made from chrome nickel steel containing.....0.31 to 0.38 per cent carbon

Heat No.	Elastic limit, per square inch.	Ultimate strength, per square inch.	Elongation, per cent, in 2 inches	Red. of area.	Vibration.	Average vibration.	Chemical analysis, per cent. Carbon.	Phosphorus.	Manganese.	Sulphur.	Silicon.	Vanadium.	Nickel.	Chrome.
7540	34,900	67,400	27.5	42.46	2,354		0.205	0.043	0.700	0.032	0.270	.....	.....	.....
7054	34,880	63,400	39.0	55.02	2,453	2,437	0.205	0.043	0.700	0.032	0.270	.....	.....	.....
					2,248									
					2,693									
333D	32,040	70,400	28.5	43.8	3,520		0.240	0.045	0.570	0.038	0.249	.....	.....	.....
333D	32,200	69,900	31.0	51.0	2,280	3,102	0.240	0.045	0.570	0.038	0.249	.....	.....	.....
333D	31,130	70,040	30.0	47.9	3,510		0.240	0.045	0.570	0.038	0.249	.....	.....	.....
8875	37,160	71,700	33.0	48.2	2,010	3,449	0.250	0.036	0.600	0.024	0.230	.....	.....	.....
8875	36,710	70,180	31.5	52.8	1,826		0.250	0.036	0.600	0.024	0.230	.....	.....	.....
229D	37,240	69,460	29.5	49.6	3,128	1,918	0.250	0.032	0.610	0.028	0.259	.....	.....	.....
229D	39,600	69,680	29.5	50.1	3,770		0.250	0.032	0.610	0.028	0.259	.....	.....	.....
227D	36,950	71,650	29.0	45.2	3,972	3,228	0.270	0.031	0.580	0.028	0.277	.....	.....	.....
227D	36,740	71,460	29.0	46.8	2,483		0.270	0.031	0.580	0.028	0.277	.....	.....	.....
470C	38,510	76,700	29.0	44.1	3,512		0.270	0.047	0.630	0.027	0.280	.....	.....	.....
470C	38,050	76,100	29.0	46.9	2,940	3,104	0.270	0.047	0.630	0.027	0.280	.....	.....	.....
470C	37,240	76,500	28.5	47.4	2,860		0.270	0.047	0.630	0.027	0.280	.....	.....	.....
473C	38,560	79,660	25.0	45.5	3,255		0.280	0.044	0.630	0.026	0.329	.....	.....	.....
473C	38,050	80,680	24.0	42.5	3,522	3,522	0.280	0.044	0.630	0.026	0.329	.....	.....	.....
473C	38,210	78,960	27.5	45.2	3,378		0.280	0.044	0.630	0.026	0.329	.....	.....	.....
624C	34,750	73,400	25.0	41.3	3,803	3,867	0.330	0.034	0.610	0.030	0.290	.....	.....	.....
624C	35,800	78,380	22.0	44.3	3,930		0.330	0.034	0.610	0.030	0.290	.....	.....	.....
461C	44,790	91,100	21.0	27.5	3,029		0.370	0.043	0.700	0.025	0.305	.....	.....	.....
461C	45,480	91,970	21.5	36.5	3,066	3,258	0.370	0.043	0.700	0.025	0.305	.....	.....	.....
461C	43,930	89,870	22.0	39.4	3,679		0.370	0.043	0.700	0.025	0.305	.....	.....	.....
481C	43,280	88,580	24.5	37.7	3,009		0.375	0.044	0.740	0.029	0.291	.....	.....	.....
481C	.....	.....	....	....	2,945	3,115	0.375	0.044	0.740	0.029	0.291	.....	.....	.....
481C	.....	.....	....	....	3,393		0.375	0.044	0.740	0.029	0.291	.....	.....	.....
447D	40,600	84,720	25.0	40.1	2,958	3,154	0.386	0.046	0.680	0.035	0.300	.....	.....	.....
447D	40,100	82,710	23.0	33.8	3,350		0.386	0.046	0.680	0.035	0.300	.....	.....	.....
9034	57,460	96,740	19.0	30.7	1,999	1,999	0.400	0.049	0.730	0.029	0.310	.....	.....	.....
9034	60,100	97,340	17.5	23.0	.....		0.400	0.049	0.730	0.029	0.310	.....	.....	.....

9215	45,660	76,620	27.5	51.1	3,000	3,265	0.235	0.047	0.575	0.030	0.250	0.145	.....	.....
9215	42,590	78,200	31.0	51.8	2,904		0.235	0.047	0.575	0.030	0.250	0.145	.....	.....
464C	48,550	82,620	26.0	47.7	2,978	3,057	0.235	0.028	0.590	0.025	0.280	0.180	.....	.....
464C	48,530	79,900	25.5	49.8	2,722		0.235	0.028	0.590	0.025	0.280	0.180	.....	.....
464C	46,740	73,900	29.5	52.2	3,471		0.235	0.028	0.590	0.025	0.280	0.180	.....	.....
479C	47,330	75,000	29.5	53.8	3,360	3,273	0.245	0.038	0.610	0.029	0.310	0.190	.....	.....
479C	46,440	72,120	29.5	52.8	3,054		0.245	0.038	0.610	0.029	0.310	0.190	.....	.....
479C	47,420	79,460	25.5	49.1	3,406	2,952	0.250	0.042	0.572	0.023	0.250	0.194	.....	.....
77E	48,400	77,500	27.5	45.6	3,096		0.250	0.042	0.572	0.023	0.250	0.194	.....	.....
77E	49,380	80,120	27.5	48.0	3,434	4,074	0.250	0.038	0.550	0.030	0.254	0.200	.....	.....
306D	47,500	75,040	27.5	50.0	4,218		0.250	0.038	0.550	0.030	0.254	0.200	.....	.....
306D	46,810	74,980	29.0	53.2	4,102		0.250	0.038	0.550	0.030	0.254	0.200	.....	.....
306D	.....	.....	....	....	3,902	4,192	0.255	0.041	0.580	0.035	0.268	0.178	.....	.....
433E	47,750	82,870	23.5	44.2	4,510		0.255	0.041	0.580	0.035	0.268	0.178	.....	.....
433E	48,010	80,860	23.5	44.2	4,356		0.255	0.041	0.580	0.035	0.268	0.178	.....	.....
433E	48,310	83,540	22.0	42.9	3,710	2,966	0.260	0.035	0.510	0.028	0.260	0.203	.....	.....
372D	47,500	80,000	24.0	39.0	2,966	3,335	0.260	0.039	0.624	0.025	0.290	0.205	.....	.....
67E	49,060	82,080	26.0	44.5	3,190		0.260	0.039	0.624	0.025	0.290	0.205	.....	.....
67E	47,420	78,480	28.0	48.0	3,480	3,476	0.260	0.043	0.576	0.022	0.260	0.190	.....	.....
74E	48,720	79,320	26.0	47.7	3,476		0.260	0.043	0.576	0.022	0.260	0.190	.....	.....
74E	49,380	80,640	25.0	50.1	.....	3,965	0.265	0.034	0.638	0.023	0.270	0.203	.....	.....
35E	41,760	79,640	28.0	44.2	4,320		0.265	0.034	0.638	0.023	0.270	0.203	.....	.....
35E	41,190	82,380	26.0	43.6	3,610	3,781	0.280	0.026	0.660	0.028	0.306	0.165	.....	.....
226D	48,120	86,220	23.5	40.1	3,834		0.280	0.026	0.660	0.028	0.306	0.165	.....	.....
226D	48,620	88,720	21.0	38.6	3,728	2,567	0.380	0.038	0.700	0.034	0.335	0.188	.....	.....
437E	64,180	111,670	15.0	28.6	2,776		0.380	0.038	0.700	0.034	0.335	0.188	.....	.....
437E	61,750	113,430	14.5	24.9	2,358									
Double annealed, "Berry"														
414D	75,440	133,840	13.5	20.5	3,053	3,351	0.470	0.042	0.730	0.032	0.361	0.185	.....	.....
414D	74,440	140,600	10.0	15.6	3,226		0.470	0.042	0.730	0.032	0.361	0.185	.....	.....
414D	73,980	133,600	15.0	21.8	3,773		0.470	0.042	0.730	0.032	0.361	0.185	.....	.....
Single anneal, "Dividers"														
9155	83,980	119,010	10.5	15.8	3,000	2,952	0.490	0.036	0.710	0.037	0.310	0.175	.....	.....
9155	86,220	123,090	10.0	15.6	2,904		0.490	0.036	0.710	0.037	0.310	0.175	.....	.....
79-D	61,660	105,750	19.0	48.4	3,810	3,831	0.315	0.039	0.540	0.026	0.306	.....	1.680	0.810
79-D	62,400	105,800	17.0	31.9	3,790		0.315	0.039	0.540	0.026	0.306	.....	1.680	0.810
79-D	64,420	106,700	17.0	35.2	3,790		0.315	0.039	0.540	0.026	0.306	.....	1.680	0.810
79-D	63,930	105,270	18.0	36.2	3,478		0.315	0.039	0.540	0.026	0.306	.....	1.680	0.810
79-D	65,920	103,670	19.0	39.9	4,287		0.315	0.039	0.540	0.026	0.306	.....	1.680	0.810
505C	69,500	115,670	16.5	34.0	3,514	3,818	0.372	0.038	0.650	0.015	0.277	.....	1.930	1.050
505C	70,420	114,350	15.5	29.0	3,889		0.372	0.038	0.650	0.015	0.277	.....	1.930	1.050
505C	73,360	113,090	18.0	39.2	3,562		0.372	0.038	0.650	0.015	0.277	.....	1.930	1.050
505C	65,420	113,500	16.5	35.2	4,354		0.372	0.038	0.650	0.015	0.277	.....	1.930	1.050
505C	70,740	111,400	13.5	29.3	3,772		0.372	0.038	0.650	0.015	0.277	.....	1.930	1.050

These tests were made on a Turner & Landgraff machine with a throw of $\frac{1}{16}$ inch and a speed of 760.

altogether aside from the Wohler fatigue phenomenon and registered potential brittleness, which the Wohler test not only failed to detect, but pronounced absent. This series of tests was made on the machine shown in Fig. 2.

The investigators then made a series of tests employing the vibratory machine illustrated in Fig. 3. It is built especially strong and the bed, or frame, is so heavy that a specimen

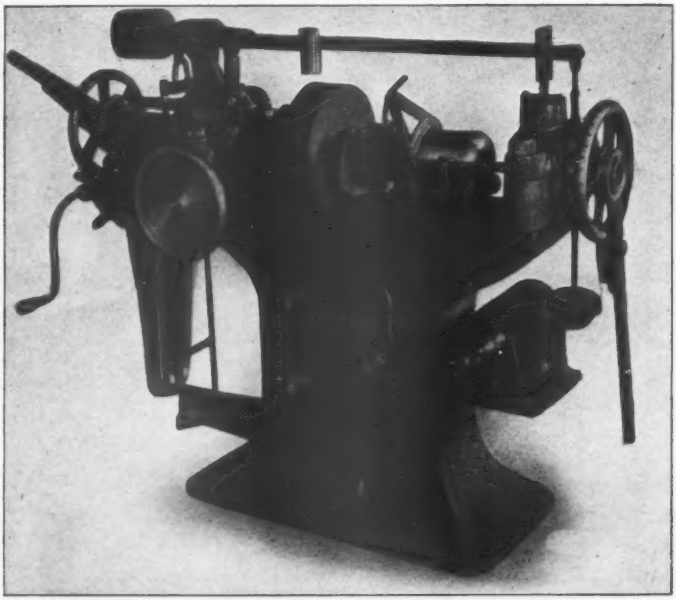

FIG. 3—VIBRATORY TESTING MACHINE, DESIGNED BY THE AMERICAN LOCOMOTIVE CO.

of steel, 1¼ inches in diameter and having an elastic limit of 125,000 pounds per square inch, can be tested without causing the frame of the machine to vibrate. This machine was described in detail in the 1914 *Year Book* of the American Society for Testing Materials.

The experiments were made on a Turner & Landgraff machine and the results are given in the accompanying table. The test pieces were 8 inches long, and by reversal, two tests

could be obtained from one sample, thereby securing an indication of the uniformity of the metal represented by the test piece. Also the thoroughness of the annealing was thus ascertained, as steel, according to its composition, or rather according to the manner in which the component elements are inter-united, is liable to deteriorate rapidly, or crystallize under the fatigue of continued reversals of stress. The data were gathered with the view of determining the results of impact or fatigue upon steel of different carbon compositions which had been annealed thoroughly in commercial foundry practice. The tabulated record shows that the static results are practically what could be expected from the different chemical compositions, yet the dynamic results prove that even though the chemical analyses are approximately the same in several cases, nevertheless the number of impact stresses are different, due as far as experiments have indicated, to the mechanical energy dissipated during a cycle of stress. It would seem that the lost energy must be transformed into heat, that there must be some form of internal friction in the material that causes wear and structural damage to occur, and that if the action is continued long enough the material will be ruptured. It seems reasonable to consider the amount of structural damage during a cycle of stress to be proportional to the energy transformed into heat, or in other words, to the area of the hysteresis loop. The shape of this loop remains similar to the shape developed under early impact of stress.

I believe that a formula which assumes that the same destructive action which occurs under high stress will continue to act with diminished intensity under low stresses, has some indirect evidence in its favor and is a safer guide for designers than a fixed endurance limit below which destruction action is assumed to cease.

I endeavored to chart curves from the accompanying tabulated results, using the carbon contents, elastic limits and ultimate tensile strength as the basis, but found that the results, when plotted, were inconsistent, making it impossible to plot a curve from data obtained from material of such a narrow range.

From my personal experience and observation, I do not believe that sufficient importance is assigned to dynamic strains in steel. The object in testing steel is to secure a product which will give longer life in the service in which it is used. Practically the only tests made are static, and while they definitely determine the efficiency of the steel in resisting severe strains, experience has shown that the strength of the steel does not definitely determine its ability to resist fatigue; and I am convinced that more failures result from the innumerable minor vibratory strains than from those which are more severe.

Discussion

THE CHAIRMAN, MR. R. A. BULL:—We will be glad to have discussion on Mr. Uhler's interesting paper. The question is absorbing the attention of a good many steel manufacturers and there is a great deal yet that has to be learned about this question of fatigue, and I hope the discussion will be lively. It would be very interesting if some other gentlemen who have had experience in fatigue tests would relate what they have learned. I might say that in our own plant we have experimented with this type of machine, but we have found a considerable lack of uniformity in our results. It has been hard to establish any standard, and I noticed that in the table that Mr. Uhler has submitted, he has experienced somewhat the same difficulty. If you look at the table, you will observe quite a wide range of results in the different bars from the same heats. I have no doubt that the author has given due consideration to that lack of uniformity in arriving at his conclusions.

MR. J. LLOYD UHLER:—As I explained in the paper, there are variations in the results, due to the heat which is generated. Two of us had an argument on the subject of heat generated while the piece was being vibrated. There is enough heat generated there to raise the thermometer up to about 140 degrees

Fahr. It does not seem that hot, but if you happen to pick up one of the ends, you drop it pretty quick, especially a piece that is vibrated about 3,000 times. The thermometer will register about 140 degrees Fahr. and shows that your line of last rupture which, if any of you have noticed, is usually in the center and on the lower ones, it is transferred out towards the outer edge of the circle.

THE CHAIRMAN:—I see that Mr. Stoughton is present and I would like to ask him what his opinion is as to the heat as a factor.

MR. BRADLEY STOUGHTON:—Well, Mr. Chairman, I have not had experience with these vibratory tests myself, and I am not able to give any opinion on that subject, but I am glad to say a word in appreciation of these results. I think it is very important that we should have a record of results of this kind, and I think we will find that if others will contribute their experience, we will find a way in time to discover the effect of heat treatment on steel castings more readily than we can by the ordinary physical test. I think perhaps, Mr. Chairman, that you yourself have some experience on that point and are able to say whether or not it is so that the results of the vibratory tests will show more clearly whether the heat treatment of the steel castings has been good or not than the results of the ordinary physical tests. From what I have heard and read on this subject, it appears to be clear that this is so, and I think it is very valuable for us to have a paper of this kind starting the subject.

THE CHAIRMAN:—I feel that a discussion of this problem is extremely apropos and that contributions such as we have had this morning are, as Mr. Stoughton says, very valuable. We all realize that there is much information concerning steel whose properties we cannot determine by chemical analysis and the ordinary tensile strength test, and we must, if we can, obtain more information as to the strength of the steel and its resistance to shock. In our own experience, as I said a while ago, we have had an unfortunate lack of uniformity and we have not been able to assign any definite reason for that, although the tensile strengths are extremely uniform, so that we have no

conclusions yet that we can report. I hope at our next year's meeting that a number of our members will have interesting conclusions to present and experiences to relate.

MR. J. LLOYD UHLER:—I would like to add one more word and state that all of these coupons, with the exceptions of very few, were taken from locomotive frames running from 30 feet up to 38 feet in length, and varying from about 6,500 to 9,000 pounds in weight.

Open-Hearth Furnace Checker Design

By W. A. Janssen, Davenport, Ia.

Almost simultaneous with the announcement of the discovery of making steel by the converter process by Sir Henry Bessemer, in 1856, the Martin brothers, in France, were attempting to make steel in a reverberatory furnace. Their efforts to make steel of medium carbon content by the melting of pig iron and low carbon wrought scrap were accompanied by failure due to their inability to obtain a temperature high enough for refining and maintaining fluidity while teeming. It was not until they incorporated the Siemens regenerator chambers with their reverberatory furnace that they were able to obtain temperatures sufficiently high to produce steel in an open-hearth furnace. Thus began the Siemens-Martin or open-hearth process which was destined to supplant gradually the maiden process for the manufacture of steel in large tonnages. The regenerators, then as now, were known as chambers wherein brick were piled in a checker-like arrangement for the intercepting or conserving of heat from the hearth gases, which on succeeding reversals, were to be used to heat the incoming air and gas to insure increased flame temperature.

That the regenerators were a necessary adjunct was recognized, but notwithstanding this, little thought or consideration was given to their design. It is only within the past decade that designers have realized the relatively low efficiency of open-hearth furnaces and have directed their efforts toward checker design to obtain maximum heat conservation.

Early Type of Furnace Design

In the early days of open-hearth furnace design, vertical checkers were placed directly underneath the hearth, the checker walls serving as supports for the hearth proper. This

practice has been abandoned almost entirely due to the weakening of the checker walls arising from alternate expansion and contraction during the periods of heating and cooling. With this attenuated arrangement the checkers were almost inaccessible for making repairs. With the addition of slag pockets, wherein the particles which are carried over mechanically with the outgoing gases are deposited by virtue of change of direction, horizontal checkers are now almost standard practice. The relative size of air and gas chambers, as designed for a furnace using producer gas as fuel, has always been a moot question. In general, it may be said that their proportions are in the same ratio as the calorific capacity of air and gas simultaneously heated. This total capacity ratio is calculated on the basis of moisture free air and gas for the temperature gradient at which they enter the regenerator and are desired to enter the hearth. This ratio is approximately that each volume of gas requires 1½ volumes of air. The empirical volume of air and gas checker, therefore, is about 1½ to 1. This ratio, however, is not strictly adhered to inasmuch as about 10 per cent more air is used than is necessary for complete combustion and the gas need not be heated to quite as high a temperature.

Aside from accuracy of relative volumes, the dependence of length, breadth and depth are important factors of design. In determining the length of the regenerator in line of gas travel to the stack, it must be borne in mind that the gases must pass through at a slow velocity rate thereby being assured of a proper cooling of the outgoing gas before going to the stack and a proper heating of the incoming air and gas before entering the furnace. In other words, the larger the cross-section and the lower the velocity, the shorter the length, and the more reduced the cross-section and the greater the velocity, the greater must be the checker length. A satisfactory checker length depending on cross-section is 15 or 20 feet. The cross-sectional area of the checker, whereby is meant the aggregate area of the free air spaces, should be so designed that the gas velocity be not greater than 10 feet per second. The gas passages must be large rather than small, as a safeguard against retardation of gas flow due to friction.

It also must be remembered that the area of these passages is constantly being reduced due to deposition of particles of slag, ore dust and other materials from the outgoing gases resulting in further frictional retardation due to the rough surfaces.

With a knowledge of maximum gas temperature and the quantity and velocity thereof passing through the regenerator, the free passage area may be readily determined. With this information and the amount of space occupied by the checker brick, the cross-section of the checker may be calculated.

Checker Depth

Aside from the length and cross-section of the checkers, the function of depth must not be lost sight of. The chief function of checker depth, aside from augmenting ideal cross-section, is to expedite the flow or travel of the incoming air and gas because of the stack-like draft effect which is directly proportional to depth. If the checkers are made deep instead of shallow, the incoming gases are forced by this natural draft to seek the hot places, and the outgoing gases to find the cool areas; thus, automatically, the regenerator temperature is equalized throughout. In early designs, when the checkers were placed beneath the hearth the draft effect of the deep vertical regenerators was greater than that of the present-day long horizontal type wherein often there is no propelling force, except the port uptakes.

The checker volume, whereby is meant the aggregate volume occupied by filled and free air spaces, usually is referred to in terms of *per ton* of furnace capacity. This volume does not include that portion above the checker brick or the flues underneath. In early design, 50 to 75 cubic feet per ton of rated furnace capacity was considered good practice. Present-day design allows between 85 to 95 cubic feet per ton and in one or two instances, up to 110 cubic feet. It is evident that the larger the checkers the greater will be the amount of heat conserved and the lower the temperature of the gases going to the stack. This, however, might be carried to such an extreme that the temperature of the outgoing gases would be

equal to that of the incoming, thereby eliminating the propelling force of the cold gases seeking the hot areas. In addition to this, the maximum temperature would be so much reduced as to be insufficient for efficient flame combustion. The high cost of refractories also would limit the building of abnormally large checkers even if they might be desirable. The chief function of the regenerators is to conserve sufficient heat units of maximum temperature to heat the incoming air and gas to a temperature high enough for efficient flame combustion. The temperature of outgoing gases from a checker so designed will be about 300 to 500 degrees Cent.

Checker Brick Arrangement

Each designer has his own opinions regarding checker brick arrangement. The fundamental fact which must be borne in mind, however, is that the arrangement must be such as to offer a maximum area for absorption and a minimum retardation to gas flow. In addition to this, the facility with which brick may be cleaned at the end of a campaign must be given consideration. In the old time arrangement which is still popular even today, wherein the brick were so laid as to produce both vertical and horizontal flues, it was almost always necessary to remove all brick for cleaning at the end of a campaign, resulting in much breakage and increased repair costs. When the bricks are laid to produce either vertical or horizontal flues, the flue may be cleaned with a boiler flue brush at the end of a campaign, thereby eliminating brick removal.

Silica Brick Checkers

It has long been the practice to use fire brick for checkers. During the past few years the use of silica brick, because of their increased conductivity, have come into favor. The first cost of silica brick is higher, but the gain in efficiency and economy warrants their use. The writer has in mind an installation in which silica checker brick were used, from which 2,500 heats were tapped before it became necessary

to replace the brick, except the first two top courses, at the end of a campaign. Some furnace designers have used standard brick shapes, others have designed and patented special shapes and others have designed brick on a basis of thermal conditions.

During the past few years there have appeared in the technical press the results of the investigators, Queneau, Wolodigne and Osann, on the heat conductivity and gas permeability of commercial refractory materials. Unfortunately their investigations were conducted under laboratory conditions and at temperatures considerably lower than actual furnace working conditions. Their results seem to indicate with certainty that the temperature at which brick are burned influences the heat conductivity, *i. e.*, the higher the burning temperature the greater is the conductivity. Even though a correct burning temperature might be attained, it would be difficult to exact such requirements from a brickmaker. It also was found that conductivity increases with temperature. The maximum temperature of the checkers, in general, is unknown until the furnace is in actual operation. To design a brick to withstand this temperature might necessitate the specification of a special mixture which might offset the desired burning temperature. With a specific knowledge of the conductivity of the various refractory materials and the amount of heat which must be conserved between reversals, a brick of ideal dimensions, which undoubtedly would be smaller than a commercial brick, might be designed. The efficient conductivity of the ideal brick would be influenced by the reducing action of carbon monoxide on the iron content of the brick mixture and by the carbon deposition due to gas permeability in the heart of the brick. The gas permeability and carbon deposition, in all probability, are the fundamental causes of checker brick deterioration. All of these theoretical considerations would seem to indicate that the ideal checker brick would be smaller in cross-section than those of present practice. The advantages which they might have are offset by decreased life, increased cost of manufacture, and breakage in handling. The decreased life would necessitate more frequent replacement of checker brick and would increase repair cost.

Of equal importance with checker design is the proper dependent design of ports, sewers for incoming gas and air, and flue to the stack. They must all be designed to permit a free and uniform passage of air and gas at the desired velocity throughout the entire area of the checkers.

Notes on Electric Furnace Construction and Operation in the Steel Foundry

By James H. Gray, New York

Electricity, as a source of heat, has been considered seriously in connection with the manufacture of steel in recent years only because, as a simple competitor of coal and gas it is expensive. When, however, it was recognized, that by the use of heat free from the contamination of oxidizing conditions, chemical reactions and metallurgical operations were made possible which could not be performed by our older methods, and that not only could the dead melting operation of the crucible be duplicated, but that materials containing objectionable ingredients could be refined and give a steel equal to the best quality known, then the use and development of the electric steel furnace grew rapidly.

So far, invention has given us two methods only of applying electric heat for the purposes of the steel furnace—the direct application of the arc to the charge in the arc furnace, and the generation of heat in the metallic charge by means of induced electric currents in the induction furnace. In the arc furnace, the molten charge is cooler than the slag which covers it, and this is a desirable condition, as the slag has a higher melting point than the steel. In the induction furnace the heat imparted to the slag is derived from the steel, while the space above the slag is quite cool. Thus, while it is possible to acquire a temperature and fluidity of the slag by which certain chemical reactions may be carried on between the slag and the metal in the induction furnace, this cannot be accomplished as readily and satisfactorily in the arc furnace.

While the arc steel furnace is merely a hearth on which steel is made, the source of heat being the arc, just as flame is used in other furnaces, the induction steel furnace is really

a piece of electrical apparatus, as it contains within itself the transformers which induce the heat in the charge.

I consider that the construction and further development of the induction furnace is more the task of the electrical expert than it is of the practical furnaceman or the mechanical engineer. Permit me then to confine my remarks to the arc type of electric steel furnace.

The Ideal Electric Furnace

My conception of an ideal electric furnace is one whose shape is a sphere. The charge would be a metallic sphere, and would be located in the center of the spherical furnace much as the yolk of a hard boiled egg is enclosed by the white of the egg. The walls of the furnace would be perfect insulators of heat and perfect conductors of electric current. The amount of current applied to the charge would then be so great that it would be melted in an exceedingly short time. When the heat was finished the furnace would split open and the charge be instantaneously ejected. Very practical considerations permit us to approach this ideal only distantly. The charge when molten will lie in a pool and the bottom of the furnace must be saucer-shaped. Doors have to be opened for the purposes of charging, manipulating slags, taking tests and making alloy additions. If we insulate the furnace too well we find that our refractory lining will melt. To introduce electric current we have to avail ourselves of the kind of current and the means of handling it most adaptable to our conditions. Therefore, our furnace is a compromise in many ways.

Hearth and Lining

For materials suitable for making the furnace hearth or bottom, we are practically confined to magnesia and silica. Magnesia is used in a basic furnace and silica in an acid furnace. The basic electric furnace, just as the basic open-hearth furnace, permits the use of a basic slag covering for the metal bath, which reacting chemically with impurities in the metal, removes them. By the use of oxides in the slag, phosphorus may be removed, but the electric furnace does more—it can work under reducing or deoxidizing conditions

which make it possible to remove sulphur and the still more objectional element, *oxygen*.

With an acid furnace, phosphorus and sulphur cannot be removed, but excellent steel can be made from high grade materials by *dead melting*, as in the crucible, and by deoxidizing the steel by the aid of the nascent silicon, which is reduced from the silica of the slag. However, there are two difficulties in this connection. If a truly reducing or deoxidizing condition is maintained, so much silica is liable to be reduced to silicon that the steel will be too high in silicon. If oxides are introduced to burn out the excess silicon, or worse yet, if no slag is carried except that coming from the melted rust of the scrap, we have no better condition than that existing in the acid open-hearth furnace.

Making a Basic Hearth

The best basic hearth is made by placing magnesia next to the steel shell of the furnace and then forming a bowl-shaped hearth by sintering-in grain magnesia which is a species of calcined magnesite. The most suitable magnesia is that which contains in its natural form a certain amount of iron oxide, as pure magnesia is too refractory for the purpose. Even with this material, it is advisable to mix with it from 10 to 20 per cent of open-hearth slag to make it sinter or frit more readily.

One method of burning-in the hearth is to make a plastic mass of magnesia, slag, hot tar and pitch, and ram in the hearth to the desired outline with hot rammers. Then a bed of coke is placed in the furnace and the electrodes lowered upon it. On the passage of current, small arcs form throughout the mass of coke and it soon becomes incandescent. After maintaining this high heat on the hearth for several days, it is burnt to a sufficient depth to make it serviceable, but the sintering cannot be forced as far as the brickwork of the bottom.

A more satisfactory method consists of placing a thin layer of magnesia over the magnesia brick and bringing this up to a white heat by means of the arcs. When a sample gouged from the bottom shows that it is no longer granular, but a plastic mass, another layer of magnesia is added and sintered

to the first, and the process is repeated until, layer by layer, the hearth is built up to the desired contour. It is then one monolithic block. Of course, this procedure is possible only in those furnaces which have the electrodes so disposed as to admit of it. This process requires about 36 hours. It is the same method which is employed in making open-hearth bottoms in America, except that with the heat of the electric arc the time consumed is much less in the electric furnace.

Having a good bottom to start with, the erosion about the slag line is repaired after each heat by throwing in a few shovelsfull of dolomite, either calcined or raw. Such a bottom lasts an indefinite number of years without ever removing it for complete replacement. Dolomite, which is a combination of magnesia and lime, can also be used for making the hearth and even lime has been used for fettling. This is done more in Europe than in America.

Making an Acid Hearth

To make an acid hearth, it has been found preferable to build up the entire hearth to the correct contour with silica brick and dust it over with silica sand. Silica brick is less expensive than magnesia brick and it is more difficult to burn-in a satisfactory bottom of sand than of magnesia.

The prime consideration in securing a sound and lasting hearth is to have it as simple as possible. It should not be complicated by any water-cooled, air-cooled, or semi-molten metallic parts or connections; neither should the bottom be composed of, nor contain conducting, but non-metallic substances. These devices, which break up the continuity of the bottom, may be put up within a hearth of small size, but those of us who have had experience with open-hearth furnaces know what "steel in the bottom" or "a hole in the bottom" means in loss of production and higher costs with a hearth of any considerable dimensions.

The walls of a basic furnace above the slag line may be made of silica, magnesia or chrome brick. Magnesia brick is the most satisfactory as regards life and the effect on banks of slag of drippings from the walls, but its high cost will equal the cost of brick and labor for several silica walls. Chrome

brick, although too soft a material under heat to be used in high walls, may be used in the low walls of an electric furnace very successfully, provided that there is no objection to a small quantity of chrome being reduced from its oxide into steel which may be specified for a particular purpose. As the chrome ore, of which the brick is made, is neutral to bases and acids, it does not cut the banks when it drips on them, and the chrome brick walls are not cut by the molten silica which runs over them from the fluxing of the silica roof, as is the case with magnesia brick. As stated, silica brick is cheaper than either magnesia or chrome brick, and, of course, is not affected by the molten silica running over the skewback from the roof. However, it is attacked by lime fumes volatilized from the slag by the heat of the arc. Also, if the electrodes become pointed by oxidation, or if the arc is too long, causing heat to be reflected by the slag to the walls, the silica brick, being less refractory than the two other kinds, is melted readily and runs down over the basic banks into the slag, cutting the banks and often causing the slag to be too acid. It is apparent then that the material to be used for the walls must be chosen after considering the various conditions under which any given furnace has to operate.

The Furnace Roof

The roof should be entirely of silica only, as no basic material has yet been discovered which will stand in the form of an arch of any appreciable span without spalling. The material for lining the acid furnace is silica throughout. Various other materials have been suggested for electric furnace work, but either their excessive cost or their failure to serve the purpose have prevented their general use.

How thick should the walls and roof be? In my ideal furnace, I mention perfect heat insulation. Unfortunately, the refractories at our disposal will not stand up under constantly applied high temperature. Heat applied at one end of a brick will cause it to melt, unless it is dissipated at the other end. Paradoxical though it may seem, ingenuity must be used to ventilate and draw heat away from the brickwork, instead of trying to insulate it. In the electric arc, we have a source

of heat of 100 per cent efficiency. To make the efficiency of the furnace as high as possible, we must endeavor to concentrate the heat, burying the arc in the charge while melting, and holding it down on the bath after melting, accomplishing the work in the shortest practicable time. Then when we have compelled our kilowatts to do their utmost, the excess or unused heat should be carried away rapidly enough to leave intact the refractories which form the furnace. It is by these means that the charge and not the furnace is made to absorb the majority of the heat, and the radiation is reduced, not by insulation, but by cutting down the time during which the heat acts.

A practicable thickness for walls is from 13 to 18 inches. I consider 9 inches to be the best thickness for the roof. It can be observed that when a furnace is new and the walls and the roof are thickest, the consumption of kilowatts is smaller than later in the campaign, but it is also noticeable that the first few inches of brickwork go much faster than the last, and that we get the real service out of the brickwork after it is so thin that the heat is rapidly conducted away to the atmosphere. An extreme application of this principle is seen in certain Girod furnaces where the roof is only 4 inches thick and where an air blast is used to cool and preserve the brick.

Electrodes

Many expedients have been tried to provide suitable electrodes and connections for the arc type electric furnace, but for the steel furnaces, all have given way to simple carbon electrodes made in sections of convenient length joined together by a nipple or screw thread which permits them to be fed into the furnace through the holder so as to consume the whole electrode without loss in the form of butts. Either graphite or amorphous carbon may be used. The graphite electrode may be graphitized after it is molded of amorphous carbon, or it may be molded of graphite in the granular form. The advantages of the graphite electrode are its high conductivity, its great freedom from breakage and its ease of manipulation. The fact that it costs more than the amorphous

carbon electrode prohibits its use where a few cents saving per ton of steel is considered important, as is the case with production on a large scale. Graphite is also a better conductor of heat as well as of electricity, and accordingly the reduction in the size of the electrode by the use of graphite is not all gain.

Size of Electrode

In the ideal furnace I considered the medium which enveloped the charge to be not only a perfect refractory, but also one big electrode. The nearest approach to this condition would be to have the bottom entirely made of carbon and have the roof consist of one very large electrode, there being no walls to the furnace. In a steel furnace carbon cannot be used for the bottom as the steel would soon become pig iron. The second compromise with the ideal would be to have the charge entirely covered with an electrode divided by insulating planes into two or three sections according to the kind of current to be used. This arrangement being impracticable, the next suggestion would be a multitude of small arcs in a great cluster which would entirely cover the charge. In this way the charge would be attacked at many points and over as great an area as possible. Of course, the questions of regulating apparatus, holders, roof coolers, accessibility to the furnace for taking tests and making additions restrain us again. The best solution, in my opinion, is to have the electrodes as large as practicable, considering what is obtainable commercially, and what will harmonize with the other necessities of good furnace design, and to increase the number of electrodes when these considerations and the size of the bath demand it.

Carbon, when kept away from oxygen, is one of the very best of refractories, and if the arc can be maintained under a relatively large surface of carbon, its heat is thrown down on the bath in the form of a hemisphere. If the electrode be very small and pointed, the arc radiates heat in all directions as a sphere and the roof and walls must suffer. In furnaces where the electrodes enter horizontally it has been found extremely difficult to maintain a roof on those of small size and impossible on those of large size. It is also noticeable

that the consumption of kilowatts per ton of steel produced is greater with the type of furnace where the heat is radiated from the arc equally upward and downward.

Assuming that the furnace is of such size that the minimum number of electrodes will be used, the number will depend on the kind of current used and on whether or not electric connections through the bottom are used. With bottom connections a single phase furnace will require one electrode, two-phase two

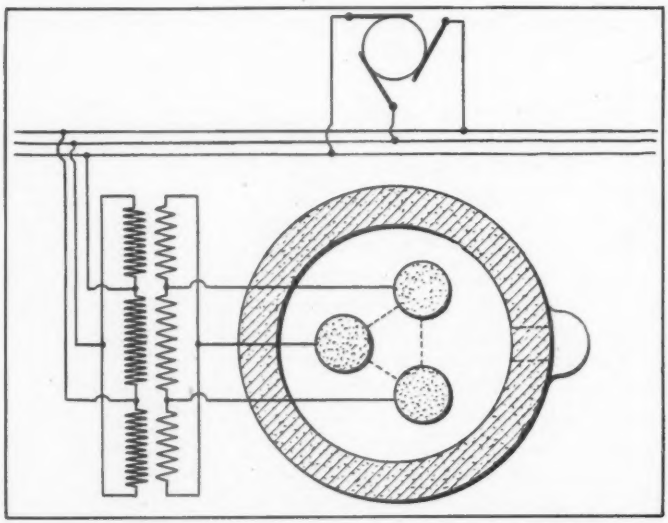

FIG. 1—CIRCULAR FURNACE WITH THREE ELECTRODES

electrodes, and three-phase, three electrodes. If no bottom connections are used, that is, if the electrodes are vertical and are in series, the current passing from one to the other through the bath, after striking arcs with the bath, or if the electrodes are arranged so as to maintain the arc above and clear of the bath, then, a single phase furnace requires two electrodes, two-phase, four electrodes, and three-phase, three electrodes. It must be borne in mind that a bottom connection is not a substitute for an electrode, though the number of electrodes may be thereby reduced, because a certain number of amperes

must be carried through the electrodes to furnish a given number of kilowatts, and the cross-section of electrodes must in both cases be the same for the same kilowatts and arc voltage. It will be noticed that for a three-phase furnace the number of electrodes is the same whether a bottom connection is used or not.

As regards the current phase which it is best to use, this question is practically settled for us, in America at least, because the current furnished by practically all the power companies, and that made in large industrial establishments, is three-phase. The reasons for the general adoption of this form

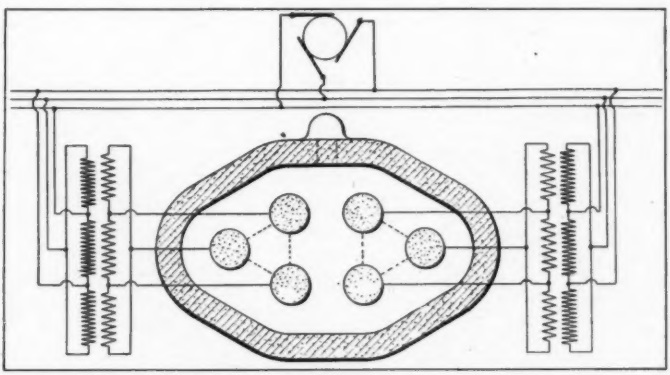

FIG. 2—ARRANGEMENT OF FURNACE WITH SIX ELECTRODES

of current are economic and will rule until some better method of generating and transmitting electricity is found.

Arrangement of Electrodes

Supposing that the size of the furnace has gone beyond that in which one set of electrodes will suffice and that three-phase current will be used, Figs. 1, 2, 3, and 4 give suggestions for the grouping of electrodes.

In Fig. 1, the furnace is circular and encloses three electrodes. As the electrodes are arranged in a triangle, the natural form of the furnace would be triangular, but the circular form gives a stronger structure and is a more practical design. The electrodes are connected in delta with the transformers and

are arranged with the pouring spout between two electrodes to facilitate slagging off.

Fig. 2 shows an arrangement of six electrodes. Here two triangles are placed with their bases parallel and the triangular form of the furnace is more nearly adhered to, considering each half of the furnace by itself. The two groups of electrodes are connected in delta with two separate groups of transformers. This arrangement is better than having the six electrodes form a rectangle, for in such a case we would have

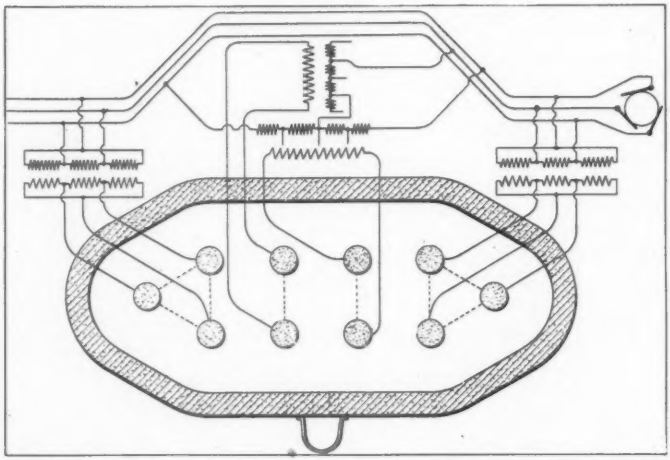

FIG. 3—TEN ELECTRODES ARRANGED IN FORM OF TWO TRIANGLES WITH A SQUARE BETWEEN

a rectangular furnace, and with the viscous basic slags of the basic electric process it is better to avoid corners or level places where the slag will rest while the heat is being poured from the furnace. With these slags, there is always a tendency for the bottom to build up, and if an accumulation of old slag from previous heats comes off the banks into the slag of some later heat there is trouble. This trouble is not experienced either with the bowl-shaped or triangular hearth.

Fig. 3 shows an arrangement of 10 electrodes in the form of two triangles with a square between them. The central

group of transformers is connected with the Scott's connection so as to give two-phase current, each phase of which passes through two of the electrodes of the square in series.

Fig. 4 shows an arrangement of 12 electrodes connected to four sets of transformers. The two middle triangles may be connected either as indicated by dotted lines or the triangles may lap over each other with two corner electrodes connected to one central electrode on the opposite side of the rectangle. Both arrangements have been found to work equally well.

Table I gives sizes of electrodes which have been found to be satisfactory in practice. It will be noted that the cross-

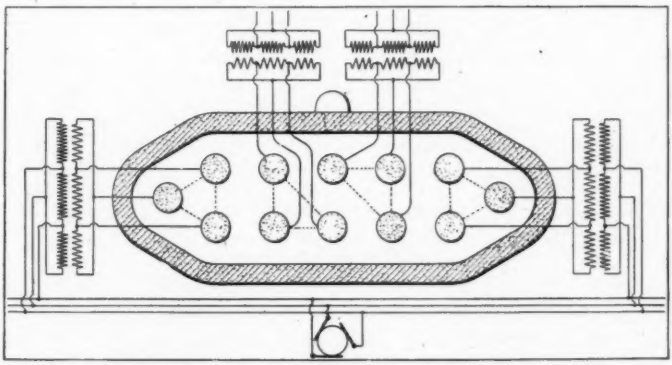

FIG. 4—TWELVE ELECTRODES CONNECTED TO FOUR SETS OF TRANSFORMERS

section of the electrode is not in absolute proportion to the size of the furnace. Account is taken of the commercial sizes of electrodes available, furnace design, and increase in current required per ton charge for furnaces of smaller size.

The electrode holder should be so constructed as to form a good electric connection with the electrode and at the same time be easily tightened and loosened. It should be water-cooled so as to prevent arcing at the connection, which destroys both cooler and electrode. Also, if the holder is not cooled it expands with heat faster than the electrode and the latter is permitted to slip down. On very small furnaces where the weight of the electrode is small and the preservation of the

holder of little moment, the water cooling may be omitted. Surrounding the electrode and resting on the roof should be a water-cooled collar or ring. This cold surface causes the fumes which arise from the bath to condense and form a smut which seals the opening between the electrode and the collar. Thus the furnace is made more nearly airtight. Without this device the flame escaping through the opening would destroy the electrode and the size of the opening would gradually increase.

Table I.

Size of Electrodes

Size of furnace, tons.	Transformer capacity K. V. A.	Amperes each phase.	Amorphous Carbon. Size of electrodes, inches.	Amorphous Carbon. Amperes per square inch of electrodes	—Graphite.— Size of electrodes, inches.	—Graphite.— Amperes per square inch of electrodes.
15	3,000	18,000	24	40	12	160
10	2,000	12,000	20	38	10	152
6	1,200	7,200	17	32	8	143
4	900	5,400	14	35	7	140
3	750	4,500	14	29	7	116
2	600	3,600	12	32	6	128
1	375	2,250	8	45	4	180

Electric Current and Transformers

The arc type of electric furnace may use either direct or alternating current. For commercial reasons alternating current is used almost exclusively and for the same reasons the use of three-phase current is becoming more general. The voltage may vary because it is transformed at the point of consumption to the pressure required in the furnace, which is relatively low. As the arc is a form of electrical resistance, the voltage employed depends on the length of the arc desired. It we adopt the principle that the arc should be confined between the bath and the end of an electrode of considerable area, then the arc should be as short as possible, at the same time keeping the carbon electrode out of all contact with the molten bath. This condition is obtained with a pressure of about 45 volts at the arc. If the electrodes are in series, then the voltage across the bus bars is 100; if the electrodes are in

series with the bottom connections, the voltage should be from 50 to 75.

When melting ferro-manganese, where it is desirable to volatilize as little of the manganese in the arc as possible, the arc is made so short that it is practically hidden in the slag, and the voltage is just above that at which an arc can be struck, namely, from 25 to 30 volts. Where a long arc is desired, as for instance, in furnaces having horizontal electrodes and in which no arc is struck with the bath, and where an arc eight or more inches long is desired, the pressures vary from 100 to over 200 volts.

For the transformation of current from high voltages to the low voltage used by the furnace, static transformers are preferable. Rotary transformers have frequently been used for this purpose in Europe, but as the loss of power in the rotary transformers is 15 per cent or more as against 1½ per cent in the static transformer, the difference in cost of current at the furnace is considerable. Also, the rotary adds one more piece of machinery to look after.

Use of Separate Transformers

Separate transformers may be used for each phase, or all the phases may be included in one transformer, as, for instance, one three-phase transformer for three electrodes. The single transformer is slightly cheaper, but an injury to one phase of the transformer may mean the ruin of the other phases, which would not be the case with separate transformers for each phase. Two transformers may be used on a three-phase circuit by running on open delta, but the advantage is questionable. Either air-cooled or water-cooled transformers may be used. If water-cooled transformers are employed the water may be passed through the water-cooling system of the furnace after passing through the transformers. The tell-tale of the furnace may be used as the tell-tale of the transformers and is always within view of the furnace operator. If the water ceases to flow through the furnace coolers the current would naturally be cut off the furnace, thus automatically protecting the transformers.

With furnaces of large size where heavy currents up to say 18,000 amperes per phase are used, and with other conditions seldom found in ordinary electrical work, the doctors do not always agree as to the best form of conductor and the amount of copper which should be used to carry the currents from the transformer to the electrodes. In my opinion, the most satisfactory construction involves the use of bus bars instead of insulated cables. I am using a cross-section corresponding to 800 amperes per square inch of copper. Where flexible cables are used, in order that the furnace may be tilted, they should be bare and may also be loaded to 800 amperes per 1,000,000 circular mils. Of course, it is common practice to load copper heavier than this, but as both the bars

Table II.

Sizes of Conductors for Electric Furnaces

Size of furnace tons.	Transformer capacity K. V. A.	Amperes per phase.	Square inches copper per phase.	Number of ¼-in. copper bars, per phase.	Number of 1,000,000 C. M. flexible cables per phase.
15	3,000	18,000	22.5	10—9-in.	24
10	2,000	12,000	15.0	8—7.5-in.	16
6	1,200	7,200	9.0	6—6-in.	9
4	900	5,400	7.0	4—7-in.	8
3	750	4,500	5.5	4—5.5-in.	6
2	600	3,600	4.5	4—4.5-in.	4
1	375	2,250	2.75	2—5.5-in.	4(600,000)

on the furnace and the flexible cables are in warm places, and it is not comfortable to have cables twisting and bars rattling under heavy loads or surges of current, I think the investment in copper is advisable. If aluminum conductors be used, the sizes will be varied to conform to the use of this metal. Table II shows how the proportions of copper mentioned above have been successfully applied to furnaces of various sizes.

Referring to transformer capacity, it will be noted that for the 6, 10 and 15-ton sizes 200 kilovolt amperes per ton are used, and that for smaller sizes the number of kilovolt amperes per ton increases as the size of the furnace decreases. So long as current is on the furnace loss of energy by heat radiation takes place and as the radiation per ton is greater

in the small furnaces, it is advisable to cut down the time during which radiation acts by making quicker heats on the smaller furnaces.

In making steel of high quality there are two periods to consider. One is the period during which the charge is being melted down. At that time the metal has an infinite capacity for absorbing heat, and if the arcs are buried in the charge an extraordinary amount of heat may be applied without overheating the furnace itself. The second period is that during which the purification and deoxidation of the molten bath is performed, the steel-making period.

Refining and Deoxidation

The refining and deoxidation are accomplished by means of chemical reactions between the elements of the metallic bath and those of the slag. These reactions require time for their completion and it is not possible to shorten this period by forcing in current. In fact, when the charge is molten and hot, its capacity for absorbing more heat is gone, and the walls and roof of the furnace cannot withstand an excessive temperature. Therefore, the supply of kilowatts must be cut down during the second period. Though we cannot shorten the refining period, why not further shorten the first or melting period by a still greater application of kilowatts? In the first place the power company usually bases its charges for current on the maximum demand and in order to protect ourselves during times in which the production is small and against periods of shut-down, considering also the relation between the power consumption during the two periods of operation just referred to, we must compromise as to how heavily we power the furnace. Also, such practical considerations as sizes of electrodes, transformers, weight of copper employed and other points of furnace design must be considered. The capacities given in Table II, though by no means fixed, have been found in practice to fulfill the conditions just mentioned.

All of the foregoing has been on the assumption that cold charges are to be melted. Where molten metal is transferred from a bessemer converter or open-hearth furnace to the electric

furnace for further refining and finishing the problem is much more simple, and a capacity of from 100 to 150 kilovolt amperes per ton of product has been found to be ample.

Power Factor

With alternating current, if pressure and current are in unison, the product of these two gives the power available. Various disturbing influences cause a lag in the current phase, in which case the available power is less than the product of the two. The ratio between these two conditions is called the power factor and is expressed as a percentage. If care be taken in the design of the furnace with regard to the disposition of the conductors with reference to each other, and to iron parts which may surround or lie close to them, the power factor may easily approximate 100 per cent.

Although in many kinds of work the companies from which power is obtained are content with a power factor as low as 80 per cent, nevertheless, a high power factor is considered desirable, and some power companies even allow a bonus on the power bill varying with the amount the power factor is above a given minimum. A well-designed arc type electric furnace using 60-cycle current should have a power factor of over 90 per cent and many steel furnaces have a power factor of 95 per cent, furnace and transformers combined.

Automatic Regulators

The arc electric furnace may be compared to the ordinary arc lamp in which an arc is maintained by keeping the carbons at a predetermined distance apart. As the carbons burn away, automatic regulation is obtained by means of mechanism included in the lamp itself. The carbons or electrodes of the electric furnace are heavy and must be lifted and lowered by suitable machinery to conform to the length of arc required to give the desired quantity of current flow. This electrode mechanism is preferably operated by motors and the impulses given the motors require the use of automatic regulators detached from the furnace. The prime requisite of the regulators is that they may be so dependable that the furnace

operator may forget their existence and give all his attention to the steel-making operation, just as we forget about the automatic regulator in an arc lamp.

Another duty of the regulators is to keep the different current phases employed on the furnace balanced, so that the power factor may not be disturbed and that the load may be

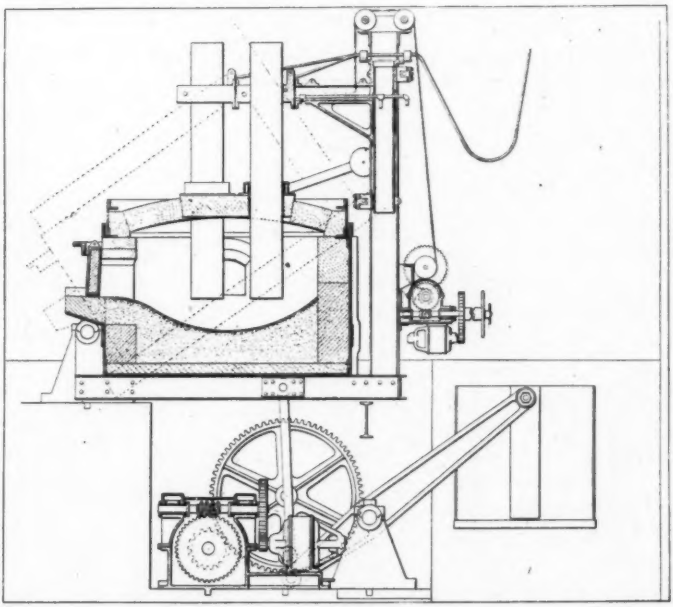

FIG. 5—SECTIONAL ELEVATION OF FURNACE SHOWING TILTING MECHANISM

satisfactory at the power house. We are dependent on the manufacturers of electrical equipment for automatic regulators, and it is for the furnace designer to select those which best fill his requirements. Several kinds are obtainable which give good satisfaction.

It is possible to operate the electrode lifting mechanism by hand, but this is an arduous task on large furnaces, besides requiring the attention of operators, which should be employed

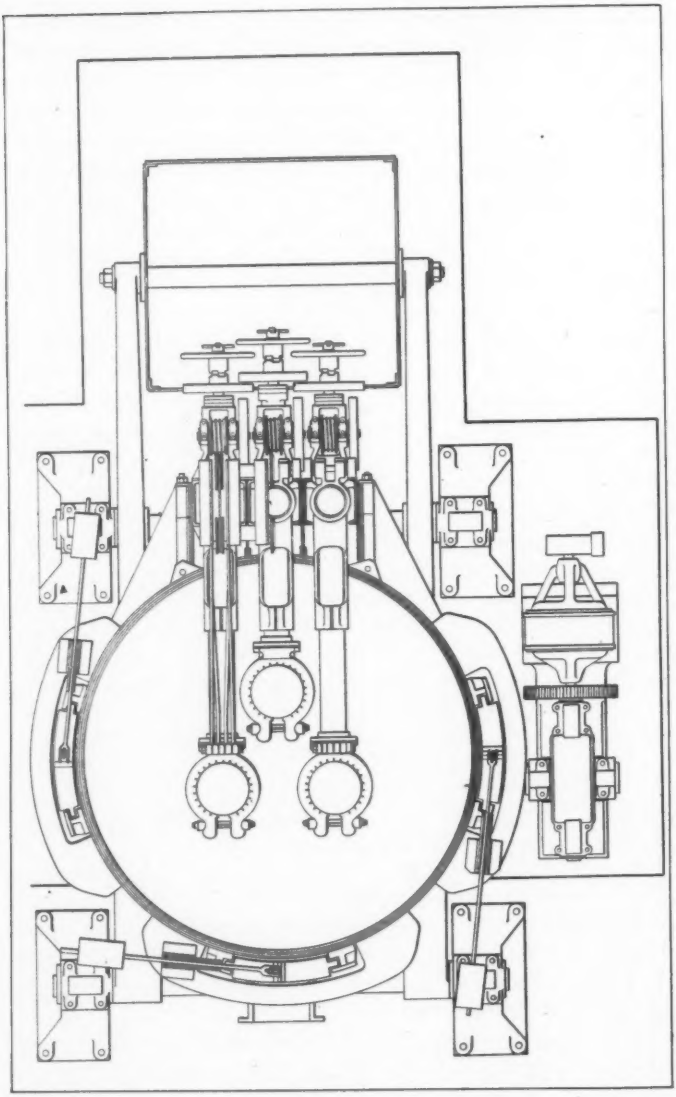

FIG. 6—TOP VIEW OF FURNACE

elsewhere. The danger of short-circuits and surges on the line with hand-operated electrodes may be minimized by the use of reactance in the transformers, or by coils at the furnace and regulators at the power house, but these devices are expensive and, in my opinion, not as satisfactory as the automatic regulator.

Furnace Shell and Tilting Mechanism

As in other features of furnace construction, the designer of the shell should be concerned with producing a structure that will retain its form under the action of brickwork which expands with heat. Also the shell must be rigid enough to carry the electrode supports without warping and getting the electrodes out of alignment. As the roof has to be replaced oftener than the side walls, the iron work which carries the roof should be easily removable. This makes it difficult to use the usual buck-stay and tie rod construction of the open-hearth furnace. This necessity is obviated if the furnace be made circular in form.

Such considerations as drawing out a viscous slag, mentioned previously, maintaining a tap hole when making heats every hour or two when refining molten metal, etc., make it desirable to have the electric furnace tilting or rolling instead of stationary. If the furnace rolls, the spout descends below the floor level during pouring. This is not an objection while pouring heats from furnaces of large sizes into a ladle in a pit. With the smaller furnaces, where it may be desirable to pour directly into bull ladles it is convenient to tilt about an imaginary hinge located near the spout, so that the spout remains practically stationary during pouring. Various devices have been used for tilting the furnace, both hydraulic and electric. Hydraulic power is not always available and considering cost of maintenance, cost of operation and convenience the electrical means is probably better.

Figs. 5, 6 and 7 show an electrically-operated tipping mechanism which has proved satisfactory in service. The furnace is lifted by means of connecting rods attached to a large gear wheel, which is driven through spur and worm gearing by a motor. One advantage of this arrangement is

that if the operator fails to cut off the current from the motor, the furnace can do nothing but descend to its original position, and at the bottom and top positions of the stroke no matter which way the controller is operated, the furnace will move in the desired direction. In the illustration a counterweight is shown which operates through levers to balance the weight of the furnace. With large furnaces which rest on rockers, the counterweight is not used, but in both cases the wheel and connecting rod arrangement gives a very smooth and readily controlled motion to the furnace.

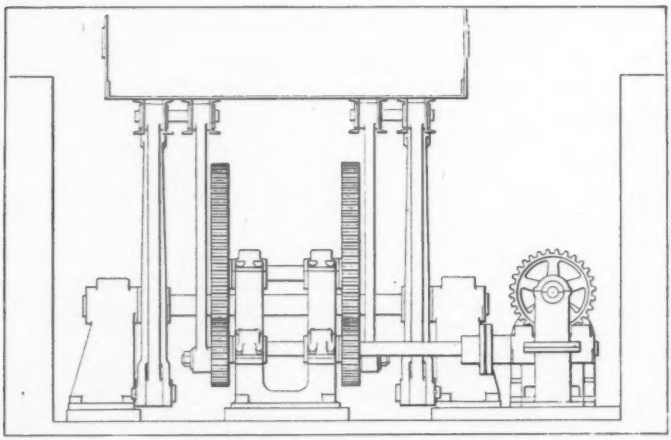

FIG. 7—DETAILS OF GEAR TRAIN

The product of the crucible was formerly the standard of excellence in steel and inventors of the electric furnace aimed to produce a metal equal in quality to crucible steel, but in such quantities that the cost of production would be lowered to a point where the margin of profit in tool steel would be increased, and high quality steel be made available for uses for which crucible steel was too expensive.

Although the first commercial electric steel furnaces were operated in France and Sweden and later in Germany, it was in America that the possibility of using electric steel for lower priced products, such as rails, was first recognized. And

it was here that the first 15-ton units were installed and three-phase current first used. Although the cost of electric steel is still higher than that of open-hearth steel made in plants of large capacity, it appears likely that when electric installations are made of such size that the production of a given plant equals that of a large open-hearth plant, the cost will not be enough higher to be prohibitive. To accomplish this, the electric furnace will be used as a finishing furnace drawing its partially refined molten charge from either the bessemer converter or the open-hearth furnace, or from a combination of these two, known as the "duplex" process. These remarks apply also to the production of electric steel for large castings which sell at a low price. Already the electric furnace, in small sizes, is successfully competing with the crucible and the small converter, either melting cold charges or refining molten metal.

To compensate for the cost of electric current considered as a fuel, the possibility of using lower priced materials is an advantage. As the crucible does no refining the materials for the charge must be of high quality and price, and the cost of crucibles and labor are important items. In the small converter, a fairly high priced pig iron must be used and the metal loss from cupola to ladle is high. Cost of production is always high from small units, and even now the cost of production in an electric furnace is close to the cost of production from a small open-hearth furnace yielding the same amount of steel per hour or per day, and the advantage is with the electric furnace as regards flexibility. It can be shut-down over night or over Sunday without keeping heat on, and without damage to the furnace.

A Steel of High Quality

A greater consideration than cost is quality. The freedom from oxides and the low sulphur content of electric steel, make it desirable for small castings. The ease with which the desired analysis may be obtained, either as regards carbon or the other elements, and the fact that alloys may be added in the furnace without loss of these expensive metals is a great advantage. It is thus possible to complete the entire steel-

making operation in the furnace and it is not necessary to resort to additions in the ladle. Also the higher density of the steel, as evidenced by freedom from blow-holes, greater specific gravity and better physical qualities when tested should not be overlooked. As heat treatment becomes more general, the field for electric steel grows larger, because of its uniformity, freedom from cracking and adaptability to great ranges of temperature.

High Temperature Readily Obtainable

For certain purposes it is desirable to have numerous small, very hot heats instead of a few large ones. Steel of such high temperature as to readily pour small castings even in lots up to five tons, can be obtained from the electric furnace without difficulty. The fact that the metal is free from oxides makes it possible to pour at high temperatures without having wild steel. The excellence of electric steel, both as regards physical qualities and freedom from defects in machining, whether heat treated or not, has led to its adoption for larger sized castings, such as knuckles for car couplers, locomotive cross-heads and castings of larger size used in particularly difficult service where quality and not price is the first consideration.

The electric furnace is now being successfully used to refine cupola iron for making malleable castings, and it is probable that a similar process would be valuable for making high grade gray iron castings.

I have merely touched upon a few points in connection with the adaptability of the electric furnace to foundry purposes, but judging from the world-wide interest being taken in the electric process, and the comparatively large number of units already installed, it seems probable that their use will become very general. As both steelmakers and foundrymen see their way clear to install units of greater capacity, I predict that the annual production of electric steel will assume very large proportions, when compared with the tonnage of steel made by the older processes.

XUM

Discussion—Electric Furnace Construction and Operation in the Steel Foundry

THE CHAIRMAN, MR. R. A. BULL:—This is certainly a very important acquisition to our transactions. We have had a number of papers in former years dealing with the electric furnace, but never have we had anything like a detailed description of the construction such as we have listened to this morning. It is due Mr. Gray that I offer an apology for the change in his manuscript. I was personally unaware of the change in his paper as in the case of Mr. Koch's paper. I am very sorry this has occurred, and I want to assure both of the gentlemen that in the *Transactions* their papers will appear exactly as they were prepared by the authors. We will be glad to have the discussion opened on this paper.

MR. J. LLOYD UHLER:—Mr. Gray calls attention in his paper to the better physical properties of electric steel over the other kinds. I have had a little bit of experience, of course, with electric steel; the experience I have had has been through courtesy, and I have tried out the product from three different concerns. It was tested for static qualities, vibratory qualities and for bending qualities, and the results that I have obtained simply have not been as good as those obtained from acid open-hearth. Whether I obtained pieces which were inferior in quality, I don't know, but I cannot bear out his statement in regard to the physical qualities.

MR. J. H. GRAY:—As I was speaking on the construction of furnaces, I have no data with me, but I can say that the tests I have seen and the tests I have made indicate that probably because of the higher density of electric steel, and its freedom from oxides, the ratio of the elastic limit to the ultimate strength is greater in electric

steel; also there is a slightly higher tensile strength; for instance, in plates for boiler purposes, firebox steel, we had to reduce the amount of carbon content because the pieces pulled had a higher tensile strength than the inspector would accept. Of course I know that you can get all kinds of results in electric steel as in other steel, but when it comes to heat treatment, I think it is quite noticeable that, in comparison with basic open-hearth and acid open-hearth steels, the irregularity in results which you get from open-hearth steel are not experienced with electric steel when heat-treated; that is, every piece you get out of many thousands is approximately the same; there is not that one bad piece which condemns a lot of others when heat-treated.

THE CHAIRMAN:—I think it will be freely admitted that quality of product has been a very important factor in the introduction and selection of the electric furnace. But there is quite a bit of steel of inferior quality which is being produced today in the electric furnace. Differences of results in making comparisons may be accounted for possibly by that very condition. There is good and bad steel made in the electric furnace, as in other furnaces.

MR. J. H. GRAY:—It is very easy to make bad steel in the electric furnace.

MR. DUDLEY SHOEMAKER:—I have been operating an electric furnace about two months in an open-hearth plant. We are able to consistently get a better elastic ratio and get over 50 per cent, which I do not think any one can get in the acid or basic open-hearth. We run our phosphorus very low and naturally our tensile strength is not as high as with a higher phosphorus steel. You can make very rotten steel, as Mr. Gray knows, and I know, if the electric furnace is not properly operated. I think most of the trouble has been that, in some places, certain details have not been properly taken care of so that the defects which are found in test bars are really not up to the furnace, but are attributable to some other cause. The possibilities are there; there isn't any question about that; whether they are realized or not, depends on the way the thing is run. As to the matter of cost of operation, that is something that has to be worked out in each location and

depends on the operating conditions in that location, but I am absolutely satisfied that the possibilities for quality are there.

MR. A. H. JANSSEN:—We, as foundrymen, in our effort to always maintain the highest possible standard in quality, are so often ready or too ready to adopt some new innovation, and, just as I said a few moments ago, in discussing the paper on converters, that there again we seem to feel that by adopting an electric furnace, all the troubles we might have would be wiped out. I think the statements as made by Mr. Gray, are made in all due justice to the electric furnace. But we have not eliminated that one big factor of personal equation and some people seem to feel that it is only a matter of turning on the juice and trusting to God and good luck to get the finest possible steel. The very fact that it is necessary for a great many people who have installed electric furnaces to have to resort to deoxidizers is not at all derogatory to the electric furnace itself, but may be due to the practice controlling the particular installation; but the point I wanted to bring out was that a good many people have a notion that the mere fact of having an electric furnace means high quality stuff.

MR. HERBERT E. FIELD:—I feel that this association should extend to Mr. Gray its hearty thanks for writing an extremely able paper and one which can be read with a great deal of interest and would prove most instructive, not only to the makers of electric steel, but to the producers of open-hearth steel. If you will carefully read the paper by Mr. Gray, you will find in several cases a few points dropped which you could not pry out of the average open-hearth man with a crowbar. It shows a tendency to tell a few things which some of us have kept "under our hats". Mr. Gray deserves credit for coming out in our proceedings and giving us a paper which is very valuable. My understanding of the electric furnace as applied to the foundry is that it is valuable not only on account of its possibilities in making good steel, but it enables foundrymen with inferior grade of material to produce high grade steel. Those of us who are at present using acid open-hearth furnaces for making government work and other work which requires phosphorus 0.025 or 0.03, find ourselves confronted suddenly with an increase in the price of low phosphorus scrap from

$14 to $21 per ton. The mills are using low phosphorus scrap which they formerly sold and the dealers are exporting a large amount. We find our casting costs going up very rapidly, while we have contracts ahead for four or five months at fixed prices. Under ideal conditions it is possible to obtain as good steel from an open-hearth furnace as from an electric furnace with as careful working as Mr. Gray gives his furnace and with as carefully trained men as he has put on his furnaces to operate them. I do not believe there is ever going to be a demand for such an extremely high grade of steel castings that the two or three per cent higher elastic limit which has been mentioned as being possible to obtain with the electric furnace is going to be a commercial advantage. I do believe that there always will be a demand for a high grade steel which can be obtained at all times from a uniformly moderate priced raw material and that the electric furnace has found a place in our foundries. I move that we extend a vote of thanks to Mr. Gray.

MR. DUDLEY SHOEMAKER:—Just one point that he made about the necessity of an expert operator and if the same expertness were used in the open-hearth, the same quality of steel would be obtained. I would like to say that our man never was on an open-hearth platform until we put him up three months ago, and he is the sole operator of the furnace and does not get any advice from anybody and is giving us the steel I spoke of; it does not require expert operation.

MR. H. E. FIELD:—Didn't you have the advice of the best engineers in the country in educating that kind of a man?

MR. BRADLEY STOUGHTON:—I understand that Mr. Field has moved a vote of thanks to Mr. Gray and I would like to second the motion. I would also like to ask Mr. Gray if he will tell us the proportion of steel made in the electric furnace by super-refinement and by direct production in the first instance, and whether he thinks the future electric furnace will partake more super-refining or act as a primary steel producer? I guess many of us would be interested to know how that works out most effectively.

MR. J. H. GRAY:—I think Mr. Stoughton's question is in line with Mr. Field's remark, that is, we are dependent on the

materials which we can obtain. With high grade expensive materials, we can at times make acid open-hearth steel which is probably nearly as good as the average electric steel. If we use a high percentage of scrap in the basic open-hearth furnace, we may make a steel which approaches acid steel in quality; but in the large steel works we have not available high grade raw materials, nor have we at our disposal a large proportion of steel scrap. While working on a large scale, we are really producing steel from ore and not from steel scrap, that is, we obtain molten pig iron from ore by means of the blast furnace and use it in the molten condition in open-hearth furnaces, using a relatively small proportion of steel scrap. This practice calls for the use of a large proportion of oxides with the charge. Under these circumstances, it is not possible to make steel of the excellent quality which is obtained from the electric furnace. A striking example is that of the Luxembourg and Westphalian districts. Germany is very largely dependent on the high phosphorus ores of Luxembourg; therefore, a basic bessemer process is used. It is quite generally agreed that basic bessemer steel is not equal in quality to either open-hearth steel or acid bessemer steel. It is not economical to use iron containing 1.75 per cent phosphorus in open-hearth furnaces so that the best solution of the problem is to eliminate phosphorus and carbon from the pig iron by blowing in the basic bessemer converter and then finishing by desulphurizing and deoxidizing in the electric furnace. In this way a steel is produced which is not only equal in quality to open-hearth steel, but is really crucible steel produced in large quantities, and competes in the world's markets with high grade steels coming from countries better favored as regards low phosphorus ore. Referring to Mr. Stoughton's question, I believe that what we are doing in the way of making steel by melting scrap in electric furnaces of small size is only the beginning of a greater use for the electric furnace. Undoubtedly, when large quantities of electric steel are produced, it will be by taking partially refined steel from basic or acid converters or from open-hearth furnaces and transferring it in the molten condition to electric furnaces for final refining or finishing. As I said in my paper, it is possible that a combination of the electric fur-

nace with the duplex process may be used in spite of the metal loss in the bessemer converter. The duplex process, that is, the use of a bessemer converter to feed an open-hearth furnace with decarbonized and desiliconized molten metal has been developed to such an extent in recent years that in many instances the steel from the duplex process is cheaper than that from the straight open-hearth process, and it seems probable that steel from the duplex process can be further refined in an electric furnace with a total cost from pig iron to electric steel not greatly in excess of the present cost of straight open-hearth steel.

THE CHAIRMAN:—I don't want to choke off any further discussion by presenting Mr. Field's motion, but if there are no further remarks on the paper, I will be glad to present the motion, which I think is very appropriate, to extend a vote of thanks to Mr. Gray for his very able exposition of this subject.

The motion was carried unanimously.

The Particular Application of the Converter in the Manufacture of Steel Castings

By C. S. Koch, McKeesport, Pa.

A writer of a paper on the manufacture of steel castings, some four or five years ago, started with the following words: "This subject has already been discussed so thoroughly before this association, that not many points remain uncovered." Since then there have been numerous additional papers. Consequently, it has been difficult for the writer to dig up something not yet touched upon, which would still be of general interest. There have been refinements in many ways, but they are generally too detailed to go into. If one looks over the *Transactions* of the Association, he will find a large amount of good matter on the converter. He will find papers on its construction, its lining, its manipulation, and its chemistry, and all the details pertaining thereto, all of which is of interest to those who are in close touch with the subject. However, little is found in regard to the various factors which have tended to make the converter a successful means for making steel in many cases and equally as disastrous in as many more; little material is available giving reasons why the converter is still being run in some foundries after 10 or 15 years, and why it was run six months or less in others. The writer proposes to discuss this subject.

Is the Converter Practical?

If, say 10 or 12 years ago, the following question were asked, "Is the converter a practical means for making steel for castings?", the total number of replies in the affirmative would have been less than 10. That is, replies from men whose experience would justify their endeavoring to answer the

question. The number of negative replies would have been almost too great to record. The proportion would have been about nine negatives out of 10 answers. If the same question were asked today from the same class of individuals, the trend of replies would be just about the reverse. The converter process has about as large a proportion of adherents today as it had adverse critics 10 years ago.

Up until about 1905, the failures greatly exceeded the successes. For the next five years, the number each way was nearly equally divided and of late years, the successes have been, probably, in excess of the failures. But we must not lose sight of the fact that news of a success is published, while that of a failure is squelched. In the early days, the failures were not due, as we might suppose, to the crudity of the process, but rather, as a rule, to the fact that in a great number of cases, the converter was being employed for purposes for which it was not adapted and was being wrongly applied. Better results have been obtained in recent years because the users have exhibited better judgment in the selection of the particular lines into which they have entered.

This can be demonstrated by an analysis of the history of the converter foundries of the United States. In making this analysis trade conditions must be taken into consideration as they vary from one locality to another.

The conclusions from this examination seem to show that the following statements are approximately true:

1.—The application of the converter to the manufacture of a general line of railroad car castings has not, to date, been a success.

2.—The use of the converter in conjunction with an open-hearth furnace has not generally met with success. That is, the open-hearth foundries, which have endeavored to add the converter to their equipment, have nearly always given up this process after a short trial.

3.—Iron foundries which have endeavored to add the converter to their equipment, except in favored conditions, have been unsuccessful.

4.—Various manufacturing companies, having a fair consumption of steel castings, have not by any means been satisfied with the results of making a small tonnage for their own use.

Why Success Was Achieved

On the other hand, the resume of the history will show the companies that have been successful, and in almost every

case it will be found that these companies have employed the following methods:

1.—They have made steel by no other process.

2.—They have adhered, as a rule, to a maximum metal line or section, or perhaps, we might say, weight of casting. This metal line or section has varied somewhat in different localities, as competition and a few other conditions have varied.

Now all these causes for failure and success can be argued pro and con and exceptions can be cited. Nevertheless if anyone is considering the application of the converter to the steel foundry business, he would do well to give due weight to the foregoing, because the statements given are not the result of theoretical considerations, but of a detailed analysis of the history of the converter business for the past 15 years.

It will be noted that in the writer's opinion, the reason for successful operation has been careful consideration of the maximum metal line or section and the question naturally arises, what is this? It will vary in different localities, but is more or less dependent on the proximity, activity and attitude of open-hearth steel foundries.

Generally speaking, converter steel costs more than open-hearth steel. Consequently, other things being equal, such plants can underbid the converter plant on all such castings as they can properly run. Therefore, if a converter foundry is in a locality where open-hearth competition is keen, the maximum weight of the castings which it ordinarily can take at a profit will be less than in the case where such competition is remote or less active. In considering this competition, there is another element that should not be overlooked. The manufacturer of large, heavy castings naturally has a lower average overhead per ton, and unfortunately in many cases, this small overhead expense is spread equally over the large and small work. In bidding, this naturally puts the converter plant at a disadvantage, with the logical tendency of restricting the converter plant to castings which the open-hearth cannot run, that is, restricting it to smaller and smaller castings.

Effect of Increased Skill in Molding

Again, the tendency in some localities is for the manufacturers of large castings to encroach more and more on the field

of the converter shop owing to increased skill in molding. It is believed by the writer that owing to various conditions, greater skill in molding difficult, medium-size castings was formerly possessed by the converter plant. During every dull period, in their desire for work, the manufacturers of large castings have gone after more difficult jobs. This has developed their skill and given them confidence.

We have already stated that in the past, success was more or less dependent on restriction to small work and these latter considerations show that in the future the converter plant will be compelled to carry this restriction further. There are, however, modifying features that should be given weight. There are converter plants strewn all over the country, located in districts where ordinary competition from the cheaper metal does not exist. These reap profits not possible to others. For example, the plant may be at such a distance from outside competition that the buyer is willing to pay a price sufficiently high to enable the converter plant to take the work with a reasonable profit. Proximity to user is always a valuable feature.

Most all converter plants, even the successful ones, handle some large work. This is obtained on the basis outlined previously, but it would not be safe to bank too much on this as being a particularly lucrative part of your business. From all of the foregoing it must not be concluded that the amount of work to be done by a converter plant is to grow less. On the contrary, new uses for steel are being found, which will give the industry more work than formerly. It is an adjustment of classes that will follow.

Shop Practice

To return more particularly to the application of the converter, there are a few fundamental principles of operation that it may be well to mention. These, again, are not theoretical considerations, but are brought to mind by a study of what has

been accomplished and *not accomplished* by the converter plants of this country:

The points I wish to make are as follows:

1.—Unusually good cupola practice is essential.

2.—The speed of the cupola should be regulated to the speed of the converter, that is, neither too slow nor too fast.

3.—Proper crane facilities are necessary.

The writer has endeavored to learn the causes, (*a*) of complete failures, (*b*) of the cases in which there was perhaps no real failure, but in which there was a discontinuance in the use of the converter, and (*c*) of mediocre success. As far as the steel-making end was concerned, these could be attributed to a bad combination of the three operations listed.

Holding the cupola back in any way whatever, to wait for the crane or the converter is not good practice, especially when the economical operation of the converter requires the use of a burden of perhaps 40 per cent steel scrap. It should not be necessary to say much on this subject to foundrymen, but strange to say many converter foundries can be adversely criticized on this point. Quality and temperature of iron should be considered and if a large number of heats are to be taken off, the time element is essential. As is well known, a 2-ton converter will produce steel at the rate of two tons every 20 to 25 minutes. If 12 heats are produced daily, an unnecessary delay of only five minutes per heat will aggregate one hour. It is well not to be obliged to start pouring any earlier in the day than is necessary on account of fumes and heat, but at the end of the day overtime is not only costly, but has many other disadvantages. Consequently, quick operation, at a uniform rate is helpful, and this can be obtained only by a well run cupola that is not too slow for the converter, and by proper crane facilities, arranged to remove the steel from the converter as soon as it is blown and to immediately refill the converter with iron. The crane should not be busy pouring off, when it is wanted at the converter. A wait means holding back the cupola, which means not only loss in time, but bad iron later in the day. That the ideal relationship of

cupola, converter and crane is not present in many foundries is not the fault of the foreman or superintendent, but is due to original faulty design.

Temperature of the Steel

Furthermore, the temperature of steel should be uniform from heat to heat and should be adapted to the class of work turned out and arrangement of the shop. The need of some shops is for steel much hotter than others. This is logical and correct and one might say that each shop has its own particular ideal temperature. This should not be higher than necessary, as heat is costly. Most shops do not seem to aim at any particular temperature. The result is changed temperature conditions daily. This puts the foreman at a disadvantage in guiding his molding practice.

If the ideal shop temperature is eventually attained, there still remains a difficulty. The steel will be too hot for some castings and too cold for others, and will burn in badly on some and not run others. To avoid this and many other foundry difficulties, the policy of the company should be toward a narrow range of sizes. It will be argued that this cannot be done in a jobbing shop, which must take whatever comes. The only answer to this is that such a statement is like many others emanating from foundrymen. We are in a rut and not until we get out, and break away from antiquated, preconceived principles, will we attain the highest degree of success. Establish your class and range of sizes and adhere to it. You will loose some work to the other fellow and at the same time take some from him. In time your plant will be operating on work for which it is best adapted and your competitor will be doing likewise. You will have made the first step in specialization. In conclusion, let me say that the first step to take in the practical application of the converter to the steel foundry is to specialize, being sure that it is on that class of work to which the converter is best adapted.

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Discussion—Application of Converter in Manufacture of Steel Castings

MR. A. H. JAMESON:—In trying to follow the text of Mr. Koch's paper and listening to the reading, I found a good many discrepancies, some of which seem to me rather vital; for instance on the third page, Mr. Koch, in reading, referred frequently to the section in places where the text lays stress upon the weight of the castings. I would take issue with him on some of the questions if they are to be taken as the text reads, but I would agree with him heartily in the paper as he read it. I should like to ask which we are to expect from him.

THE CHAIRMAN, MR. R. A. BULL:—I noticed the discrepancy.

MR. C. S. KOCH:—I wanted to avoid the use of the word *weight* entirely. I notice that in the text it uses the word *weight,* which has been changed from my term. As I see it, the weight does not necessarily mean anything. In our district, an open-hearth foundry will take a 300, 400 or 500-pound casting if it has a section sufficiently large; on the other hand, we can take a thousand-pound casting that the open-hearth people cannot run satisfactorily; the point is not, to my mind, a matter of weight at all, but a matter of the metal line or section of the casting, not only all the metal line or section, but a minimum section which occurs in any casting. You might have a casting which is an inch in some places and disregard that and take a part of the casting which is only ⅜-inch. We have a great many people speak to us in that way about the weight and try to change it around to the metal line or section. I believe here in the east they say sectional metal more than we do, but it is the thickness of the metal that is the point. That, I believe, is the one question. Does that answer your question?

MR. A. H. JAMESON:—That answers my question.

MR. BRADLEY STOUGHTON:—I would like to take issue with Mr. Koch on one point. In his abstract of the paper he says that ten or twelve years ago, nine out of ten converter foundries were failures. I know that ten or twelve years ago a good many converter foundries were failures, but my records do not show anything like such a large proportion, and I would like to know on what he would base such a statement.

MR. C. S. KOCH:—I believe that if you listened to me, you would note that I said nothing of that sort. Again, the abstract was not made by me and, as I say, the statement did not come from me at all. What I said, if I remember correctly, was that nine out of ten steel foundrymen, regardless of whether they were converter, open-hearth, crucible or what not, would have answered ten years ago that it was not a success, not that they said that nine out of ten had failed, but that they did not believe it was a success. I might say that the paper was changed in many instances and perhaps it is only fair to say that I read my paper exactly as I had sent it in, and if I read it somewhat clumsily, it is due to the fact that I assumed I would have a printed copy of it and the copy I have here is one that has been erased by the stenographer and several others, so that it is somewhat difficult to follow. I did not get a printed copy of the paper until after I left home. There are not only these two discrepancies, but a great many others, as you probably noticed in endeavoring to follow the paper.

THE CHAIRMAN:—It is only fair to Mr. Koch to apologize to him for any corrections that may have been made in his manuscript, such as have been mentioned. I am personally unaware of the occasion for this or the source of it. I want to assure Mr. Koch, however, and others present, that the association has no desire or inclination to change the meaning of the text of any of the papers prepared. The only thing I have personally noticed in the paper which bears particularly on the question Mr. Stoughton raised, is the first sentence in the first paragraph on page two, which says, "Up until about 1905, the failures greatly exceeded the successes." Of course that does not say nine out of ten. That particular statement is correct. Isn't it?

MR. C. S. KOCH:—Yes, that is true, and I think I could

back that up with figures, but I mean that I did not say there was such a small batting average, if you please to put it that way; that there was only one out of ten that ever got through with it.

MR. S. E. JONES:—I would like to ask Mr. Koch if he would mind qualifying the statement he made as to the failure of converter equipment; that is, I mean by that, give the reason, the average cause for failure.

MR. C. S. KOCH:—I think that a very large majority failed simply because they got into the wrong kind of work. In other words, they got out of their game and tried to buck the open-hearth game, if you please to put it that way. That, understand, has to be modified in every district into which you go. For example, in the Pittsburgh district, in which we are necessarily restricted more closely to certain castings than somewhere else, because there are a large number of open-hearth foundries, competition is keen and they are all alive. I could go somewhere else and would not be restricted to that small range nearly as much, and I think that a great many of them were often started in what you might term open-hearth districts, and before they got down to cases and found out their mistake; or they didn't get into a cost system, or what not; they were taking this work and trying to beat the open-hearth game, or before they found that out or would believe it, they were financially in trouble.

MR. S. E. JONES:—Don't you believe that a large percentage of failures was due more to a lack of study of the principles of the production of converter castings rather than to the location? You mention in your paper something about the practice, converter practice in connection with perfect cupola practice and ideal crane conditions; in other words, an efficient organization handling the metal. Now then, it seems to me, from my observation that failures in converter steel production are due almost entirely to the lack of knowledge of making steel in the converter.

MR. C. S. KOCH:—I mentioned this cupola and crane matter as being one that was very vital; it is the only one, you see, that I do mention. Again, as I said, these statements are based not entirely on what I believe, but are simply made as

an analysis of what happened. In other words, here is a foundry we know; we knew about it before it started, watched its history and in a year or two it was down. What was the cause of it? If you tabulate all those ideas, you come to the two considerations I have mentioned—the wrong field and perhaps bad arrangement of this matter I am speaking about and not to the fact that the man did not have a good blower, nor to the fact that the man did not know how to handle his molding end, or cleaning end, or what not. There are failures due to that, but the great majority of failures have not been due to it, and the great majority are what you might call small failures, people who went into it in a small way. This crane business can cause a whole lot of trouble in a whole lot of different ways that we haven't got time to go into, but I think that two things, first the business end, that is, kind of work they went after, and the second this cupola and crane end, were the causes in most cases. Now and then you will find some man who may have had trouble with his blower, etc., but he went to some other converter foundry and rectified them, and if he had enough money, he'd get away from the difficulties.

MR. S. E. JONES:—True, if he would study his condition and the scientific production of castings, but it strikes me that the majority of all failures, from my own observation, are due to the lack of knowledge rather than to location, although location certainly will cause failure if a man tries to compete with the open-hearth in a large open-hearth field; he must take something the open-hearth cannot handle, if he is in the locality of an open-hearth furnace, but I have seen failures where there was no reason for failure other than a lack of knowledge on the part of the owner.

MR. C. S. KOCH:—I will agree that that is so, but I maintain this, that in the majority of cases, or if you choose to put it in the greatest number, failure has been due to these things. There are cases like yours where a man did not have enough knowledge of the game to work it out and had to rely too much on other people, and things of that sort. There is no doubt but what you are perfectly correct in that, but the great majority of failures are not due to this.

MR. S. E. JONES:—We are in the converter business and

manufacture converters, and the point I wish to emphasize is this—that a careful study of the converter production will enable a man, in a reasonable locality, to produce steel castings profitably with the converter.

MR. C. S. KOCH:—I agree with you perfectly. If he will avoid these two things and then use reasonably good care, there is no question about it at all; that is what I say, the successful ones did this; there is no question about it.

MR. W. A. JANSSEN:—It occurs to me that the subject is so very broad that the author, although he handles it very nicely, is taking the general proposition and then further trying to detail it due to the failure of some local shop conditions. Not being a converter man, but having known of some failures of converter plants, the fundamental cause, as I see it, is, in a general way, the lack of understanding of the converter business, and this has been largely brought about due to the fact that so many gray iron foundries have been swept away by the onrush of the necessity and demand for steel castings and have been led to believe that the making of steel castings by the converter process is only a secondary operation after having melted their metal in the cupola. They have found by bitter experience that this is not quite as simple as some would have led them to believe. The result is, too, that many of them have taken the converter business as a side issue and as a side issue it has remained, and it has not been a successful venture with individual plants, but that would hardly mean that the converter practice was necessarily a practice which would mean failure in every case, or even in a small percentage of cases.

MR. C. R. MESSENGER:—Mr. Janssen brought up some of the points I had in mind, but I was going to ask Mr. Koch if he had not noticed that there was a relation to the cleaning end and the balance of the equipment, besides the difference in the cost of metal? In other words, it seemed to us that, even though we had a higher cost of metal on certain small work, we found that in a good many cases we could compete with the open-hearth because they did not care for the smaller work and were not rigged up to handle it in the balance of the foundry. They could pour it cheaper than we could and could mold it cheaper than we could, and I wonder if he had any

definite opinion as to just about where that point was in weight and in section.

MR. C. S. KOCH:—I agree with Mr. Messenger that sometimes the weight will come into it—we will say, volume of the casting.

MR. C. R. MESSENGER:—That is better than weight.

MR. C. S. KOCH:—I tried first to bring out the point here that the open-hearth people have changed somewhat, that is, the people with whom we come in contact; they have increased in skill in molding. Now, if you please, I will put it skill in handling smaller volume castings. They are now taking castings which many of them would have turned down five years ago and which all of them would have liked to turn down ten years ago. This is for the reason that they have changed their practice, due to the fact that, when work is slack they will take anything they think they can run, and, having got it into their shop, they are developing their shop practice in many cases, as you say, in the cleaning room, in molding, in fact, all through; perhaps, until recently, some never had a snap flask in the open-hearth shop to handle the small work efficiently, and they keep going further and further, and they are going to take more from you and from us as time goes on until it gets down to the proposition of just what they can run; they will be able to handle it just as well as you and I can in time. Some of the open-hearth foundries are away ahead of the others in that respect.

MR. C. R. MESSENGER:—Have you any idea what a 5-ton open-hearth can run, what proportion of small work can they run and how thin sections can they get, that is, what proportion out of that 5-ton heat? You know that the last of your metal bothers you a little. How much does the last of a 5-ton heat bother an open-hearth man?

MR. C. S. KOCH:—I don't know because I have only seen one 5-ton open-hearth plant run one day. That particular man was not going very much under ¾-inch in any casting. He was in a district where he could have obtained a lot of thinner, lighter work. That is the only way I can answer your question. I simply drew my conclusions from what I saw and have stated here, and you will have to draw yours. This man was an eminently practical foundryman. He could have

run his open-hearth furnace a little hotter had he wanted to do so. It is a question whether it would have paid him to do it.

MR. C. R. MESSENGER:—And that cost to him, how would it compare with the converter cost?

MR. C. S. KOCH:—You are bringing up the question, why not make some of these lighter, thinner castings with a 5-ton open hearth?

MR. C. R. MESSENGER:—That's what I am getting to.

MR. C. S. KOCH:—You know the trouble he is going to get into is in pouring them off, if he has five tons of hot metal to pour into small molds.

MR. C. R. MESSENGER:—Is it practical?

THE CHAIRMAN:—Where is the dividing line?

MR. C. R. MESSENGER:—Yes, that is what I am after.

MR. C. S. KOCH:—I don't know that I should say in answer to that; you mean the section of metal?

MR. C. R. MESSENGER:—Well, the section of metal and everything considered.

MR. C. S. KOCH:—Well, I think that is an awful big question to answer in a few words. I think you would have to know what district a man is in, what class of castings he is going into and a whole lot of things. If he is running industrial car work, that doesn't have to be run up in every point finely, he might get away with it. If he gets into some truck work and has to run every point finely, he won't get away with it. It depends on the district he is in, perhaps. I do not believe personally that the 5-ton open-hearth proposition is much cheaper than a converter for tonnage; I don't know anything about the figures, I can only judge from the figures on a large open-hearth furnace, but I believe your expense on the 5-ton open-hearth will go up so fast that you will be in the converter game pretty closely.

MR. C. R. MESSENGER:—That's what we believe.

MR. C. S. KOCH:—It is unnecessary to say that we believe that, or we would have a 5-ton open-hearth.

THE CHAIRMAN:—I see Mr. Muntz here; he might want to make some remarks about the suitability of a converter.

MR. G. MUNTZ:—I don't believe I could add much to what has been said.

MR. W. A. JANSSEN:—During this discussion several times the matter of the district in which these castings were made was brought out. I cannot understand that unless it means that it is in a locality where you might have a converter and an open-hearth working in competition. That resolves itself back to the question the gentleman asked a few moments ago, as to the relative adaptability of a small ton open-hearth as compared with its ability to run a similar section in a converter. Not being a converter man, but coming from an open-hearth shop and being more familiar with that practice, I can answer in a general way, that, in a general way you are able to run the same sections you would be able to run in a converter. I have in mind a 3-ton open-hearth furnace in acid practice, in which they have very little change in their end metal as one would have in basic practice, and I have seen castings made by those people efficiently which would compare in the section which would be usually understood as coming within the classification of converter possibility and adaptability; so it seemed to me that the matter of district has really no connection; it is the efficient operation of both types of furnaces for producing the metal.

THE CHAIRMAN:—Don't you think, Mr. Janssen, that if we might have an opportunity to examine that gentleman's monthly cost sheet, we would find that his melted metal cost would be pretty high?

MR. W. A. JANSSEN:—It possibly would; I would not have brought this matter up at all as a comparison if I had not known something of the costs of the particular foundry to which I refer, and as I recall it, they of course were higher than the metal produced in the larger units, but they compared very favorably and were lower than converter costs, as I recall them now.

MR. C. S. KOCH:—There is no doubt that an open-hearth furnace can be run very hot. Speaking about the large open-hearth plants that are taking some of that thin work—there is a gentleman right here in the convention now who is in trouble; his company is insisting that he make some of this lighter work; the result is that it has been necessary for him to do everything possible to get the hottest metal he can get.

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He claims that his cleaning room cost, labor, has gone up $8.00 a ton because that hot metal is getting into the larger casting; that is, he is trying to pour very thin castings and heavier section castings with this very hot metal, and therefore he is getting into trouble. I talked a long while yesterday afternoon or the day before, with that gentleman, and he wants to know what he is going to do. Now, various open-hearth foundries have been up against that thing and they put in converter plants, as I mentioned in the paper. They were very good foundries and everything else, but they went back to their open-hearth plant again and left the small, thin work go, and all the time you are finding some open-hearth plant that endeavors to do that. The point is, in going all over the country, watch and see how long they continue doing that, that's the proof of the thing.

MR. DUDLEY SHOEMAKER:—I have been running an open-hearth plant on high steel castings for six years, but we stand ready at any time to make anything in an open-hearth furnace that can be made in a converter; you can get any temperature in an open-hearth that you can get in a converter; the proposition is purely one of temperature. If the open-hearth furnace can be designed along lines of giving excessively hot temperature and you have enough work to take the entire output and put it in light stuff, you have got a condition where you can get a metal cost three or four dollars lower than the metal cost in the converter. If you haven't got enough work to put it in one line of castings, you have a condition such as Mr. Koch has outlined, where you are putting hot metal in heavy stuff and getting bad results, so we feel that converters are more for installations where there is not enough work to warrant the entire output of a furnace designed for high temperatures.

THE CHAIRMAN:—What you have just said, Mr. Shoemaker, bears upon an interesting question which followed some remarks made before you came into the hall. Is there any further discussion on this paper?

MR. BRADLEY STOUGHTON:—This paper of Mr. Koch's is going to remain for a long time a classic on this subject, therefore I think one point should be added to it. He has

covered everything I can think of, with one exception, and that is the matter of capital. You can go into the small converter business with relatively small capital, and the result has been, in many cases, that people have gotten a little bit of capital together and started a converter foundry, with the result that when they had their installation complete and commenced to do their work, they did not have sufficient working capital. Now there is always the voice of the tempter in the land to persuade one to do that, but it is a bad thing to do; a man had better stay out of this business unless he is going to have sufficient working capital so that he can run along for the first few months without cutting prices below the proper point in order to get money back into his shop to pay his pressing bills, and I think Mr. Koch will agree with me, and that, for the sake of the record, this ought to be added to what he has said. There is another point about starting with insufficient capital. Many converter plants start with a very small capital and they really skimp themselves on points which afterwards make their operating expenses high; for example, they use cupolas which have not sufficient height from the tuyeres to the charging door, so that those cupolas operate uneconomically, and also they skimp themselves on the crane capacity and on a sufficient variety of flasks, so that if a man has to make a small casting in a large flask, it costs him a good deal of money.

MR. C. S. KOCH:—I agree with Mr. Stoughton thoroughly; however, one cannot go too far into a thing like this. I think that for a long time we converter fellows have been subjected to this criticism, that we have exaggerated the difficulties of the converter game. People, therefore, say "You are trying to keep people out of it". Therefore, you are on ticklish ground when you get too far, in a paper of this kind, into such things as the amount of capital and things of that sort; a wrong motive is attributed to a man who speaks of them. We want to avoid these things as much as possible in a society of this kind; we want to try and tell as near as possible, it seems to me, what the actual conditions are; it is better, as I have tried to put it, to analyze what has happened in the last 15 years and let people draw their conclusions from that.

XUM

Partial Report of the A. F. A. Committee on Steel Foundry Standards

The Committee on Steel Foundry Standards at the suggestion of the compiler of this partial report, who was much interested in the subject, and who offered facilities for research at the plant of the Commonwealth Steel Co., undertook during the past year an investigation into the relative advantages and disadvantages of atomizing fuel oil with steam and air in open-hearth steel furnaces. Subsequently, the American Steel Foundries kindly tendered the use of their Indiana Harbor plant for making the tests on an acid furnace. The desire was to determine which of the two atomizing agents is preferable from every standpoint including cost, time, quality of product, etc., both in basic and in acid practice.

It is of course necessary to summarize the basic and acid tests separately, and it has seemed most satisfactory for each series of tests to be reported by the member who gave the tests his constant general supervision, and who was consequently in closest touch with all details of the investigation. Accordingly, what immediately follows are the results of basic tests made under the general direction of R. A. Bull, who acknowledges the valuable personal assistance, on the ground, of W. C. Hamilton of the American Steel Foundries and W. A. Janssen of the Bettendorf Co. The basic tests were under the immediate observation of E. R. Swanson, assisted by John H. Locke and others of the Commonwealth Steel Co. A supplementary report will cover the tests on an acid furnace, made under the general supervision of Dudley Shoemaker, chairman of this committee.

Basic Tests and the Furnace

The tests were begun March 29, this year, at the plant of the Commonwealth Steel Co., Granite City, Ill., on an open-hearth furnace having a magnesite bottom, the bath of this furnace at the slag line being 21 feet 4 inches by 9 feet 6 inches

in area, and 21 inches deep at the center, 2 feet back of the tap hole. The furnace at the time of the tests was receiving initial charges of pig iron and scrap amounting to 56,000 pounds. The exact time for beginning the tests was purposely regulated by the condition of the furnace, on which test operations were begun when it was in perfect normal condition, in the middle of its campaign. It had made 275 heats since the last general repairs. The furnace presented no extraordinary details of construction from those usually found in steel foundries, and had no water cooling equipment. The furnace stack was 100

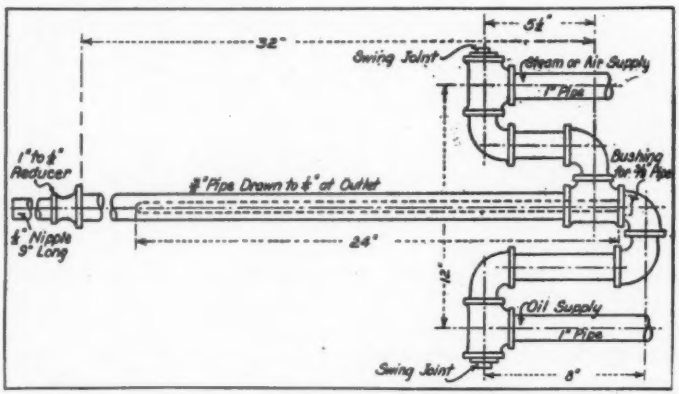

FIG. 1—DETAIL OF OPEN-HEARTH OIL BURNER

feet high, and had an inside diameter of 48 inches. The oil burner is shown in Fig. 1. The oil was delivered to the burners at a pressure of 95 pounds per square inch, and the effect of pump pulsations was counteracted by a standpipe and air cushion.

The oil used was that which is commercially known as fuel oil and came from fields near Lawrenceville, Ill. Samples for B. T. U. determinations were taken at 6-hour intervals throughout the tests. They proved so uniform that no corrections were considered necessary in the figures for oil consumption. The average B. T. U.'s per pound were found to be 19,066, and the average specific gravity was 0.914, which

closely corresponds with 23 on the Baume scale. This oil is of very satisfactory quality for open-hearth use and averages about 0.33 per cent sulphur. A temperature of 125 degrees Fahr. for the oil was adopted and maintained throughout the tests, as preliminary observations indicated no improvement at lower or higher temperatures.

All instruments were carefully calibrated just prior to tests and immediately following them, and any necessary corrections were made as shown advisable by the calibrations. These corrections were found to be of very slight importance in any case, due to the accuracy of all the instruments used.

Both steam and air were measured by a General Electric recording interchangeable flow-meter having an integrating attachment. Three separate calibrations of this instrument showed an average error of 0.2 per cent plus. The uniformity of the results in these calibrations was marked and the accuracy of the instrument was very gratifying. Grateful acknowledgment is here made of the courtesy of the General Electric Co. in loaning this instrument to the Association without expense for these tests. The kindness of that company is the more appreciated, as it did not carry the desired type in stock and made this instrument especially for our use.

The oil consumption was measured by a Bowser meter, which together with the instruments enumerated below and not otherwise noted are the property of the Commonwealth Steel Co., and have given satisfactory service. Draft pressure and flue temperature at the base of the stack, also temperature of the oil were determined by Bristol recording instruments. The temperature of the bath in the furnace was taken by a Scimatco optical pyrometer. The uniformity of the oil temperature was maintained by means of a Sylphon automatic temperature regulator. The burners and furnace valves were reversed on signal from an automatic alarm attached to an ordinary clock The time when valves and burners were actually reversed was determined by a recorder made by the Eco Magnetic Clock Co. The tensile tests were made on a Riehle 100,000-pound machine, and on an Olsen 100,000-pound machine owned by the American Steel Foundries. Two sets of bars were made, one having rough turned grips, and the other having threaded grips. The

apparent elastic limit on the threaded bars was determined by means of a modified Berry strain gage having a two-point contact, reading to 0.0001 inches and owned by the American Steel Foundries. The Johnson method was employed in plotting

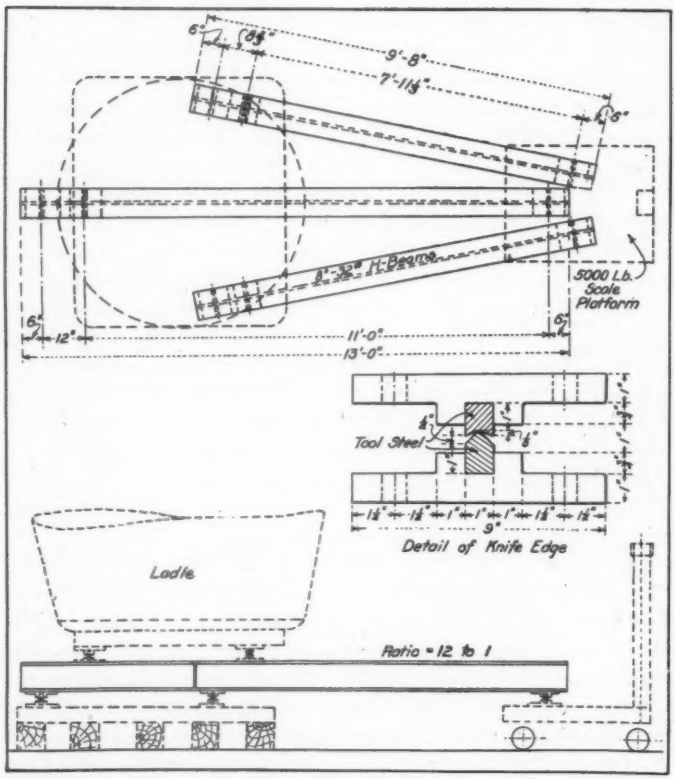

FIG. 2—ARRANGEMENT FOR WEIGHING STEEL IN LADLE

curves representing the stretch of the threaded test pieces. The threaded bars were pulled on the Olsen machine. The bars with rough turned grips were broken on the Riehle machine, and the yield point of these bars was determined by the drop of the beam.

Many expedients were suggested and tried for determining the loss by oxidation. These resulted in a very satisfactory method for weighing the ladlefull of steel on a Fairbanks 5,000-pound rolling mill scale, arranged as shown in Fig. 2. This scale was calibrated several times by placing objects of determined weights in varying amounts on the platform designed for the ladle, to check calculations and verify the belief of the Fairbanks representative that the mill scale would accurately register the expected overload. The average of several test-weighings which were reasonably uniform showed the following results, from which a curve was plotted for the correction of weights observed:

Load on scale, pounds.	Error, per cent.
51,086	1.2 plus
69,966	1.7 plus
74,473	1.93 plus
81,453	2.44 plus

The amount of metal represented in any "back pits" rabbled out of the spout after removal of the ladle was added to the weight of the filled ladle, and after the heat had been poured any sculls remaining were taken into consideration in determining the tare weight, which included not only empty ladle, but stopper-rod and slag. The scale was placed within 50 feet of the furnace on the pouring floor, and the weight of the ladle was determined with a loss of only a few moments' time. It will be observed that the length of the lever arm readily adapted the use of a scale of such small capacity for this work. The knife edges for the beams were especially made of hardened tool steel. A substantial temporary foundation was placed under all parts of the scale, and a level condition maintained. The bail was removed from the trunnions before the weight was taken.

General Conditions Maintained

A draft at the base of the stack representing 0.8 inch of water was adopted and maintained throughout the tests, as this was by previous observation believed to be most satisfactory. Periods for reversal of furnace burners and valves were at 15-minute intervals, and so regulated for the same reason.

In the steam tests, the atomizing agent was delivered from boilers showing 125 pounds gage pressure and was superheated by passing through a coil 24 feet long, made of 1-inch pipe, placed through the flue just outside the damper and throttled to a pressure varying from 40 to 60 pounds as desired at the burner. A pressure of 60 pounds was maintained until the stock was melted and the pressure was then reduced to 40 pounds to finish the heat. The degree of superheat varied somewhat and averaged 140 degrees Fahr., which was considered to be conservative for yielding the best results, as ascertained from experience. All members of the committee unhesitatingly agreed that the steam should be superheated, as otherwise there would be reduced efficiency due to saturation, the degree of which would vary greatly in different plants due to distances from boiler rooms and other local conditions.

In the air tests, the compressed air was delivered from a receiver showing 80 pounds gage pressure and throttled to a pressure of from 40 to 60 pounds as desired at the burner. The average temperature of the air was 97 degrees Fahr.

In computing oxidation losses, all the iron content found to be representative of the following materials used in the heats was taken into account:

	Per cent iron
80 per cent Ferro-manganese	12.726
50 per cent Ferro-silicon	40.43
12 per cent Ferro-silicon	86.154
Iron ore	66.438

The amount of metal charged included not only the iron content in these materials but of course any pig iron found necessary to add after melting. Pig iron and scrap were debited at 100 per cent. The yield was regarded as 100 per cent of the steel produced.

Stock Charged

In each heat 31,000 pounds or 55.3 per cent of chill cast northern pig iron, 17,000 pounds of reasonably heavy foundry scrap, 8,000 pounds of scrap rails, and 8,400 pounds of lime-

rock were initially charged. An average analysis of the pig iron shows the following:

	Per cent
Carbon	3.250
Phosphorus	0.159
Sulphur	0.040
Manganese	1.030
Silicon	0.840

An average of numerous samples of scrap rails used, shows the following:

	Per cent
Carbon	0.330
Phosphorus	0.108
Sulphur	0.067
Manganese	0.800
Silicon	0.050

The average carbon content in the foundry scrap was 0.20 per cent, and the percentages of other elements can be assumed to agree closely with the averages noted in the steel produced during the tests. Purposely the quality and physical characteristics of the metal charged were maintained uniform and the variable constituents kept low in all the heats so far as conditions permitted, in order that oxidation loss, quality of metal, etc., might be gaged intelligently.

Heats Treated With Compressed Air

It is instructive to give some detailed figures as well as averages in the log of observations. The tabulated results in Table I are self-explanatory.

Determinations in all heats for constituents of slags were made and are indicated by the following summary:

	SiO_2 Per cent.	CaO Per cent.	Al_2O_3 Per cent.	Mn_3O_4 Per cent.	P_2O_5 Per cent.	S Per cent.
Average....	12.66	52.32	1.76	5.22	1.49	0.08
Minimum...	11.06	51.28	0.82	3.04	1.38	0.05
Maximum..	14.37	54.23	3.06	6.59	1.59	0.11

The detailed analyses of FeO, Fe_2O_3, and MgO are sufficiently important to justify recording in full:

	FeO Per cent.	Fe_2O_3 Per cent.	MgO Per cent.
	13.97	2.83	11.74
	15.48	1.42	8.82
	16.66	0.25	10.39
	13.04	4.55	9.66
	13.77	0.36	9.27
	14.46	4.23	6.94
	17.56	5.34	6.08
	15.88	5.30	5.65
	14.38	3.23	6.81
	13.86	5.13	7.83
	11.69	5.74	7.35
	17.12	3.74	6.96
	14.34	3.56	9.64
	14.88	4.38	6.66
	15.60	5.19	5.07
Average..	14.84	3.68	7.93

The physical and analytical tests showed the expected uniformity and it would be superfluous to show them in detail. No heat treatment whatever was given any of the test specimens, which insured accurate comparisons of the metal as delivered from the furnace. The average analyses and physical results of tests taken from the middle part of each heat are as follows:

	Per cent
Carbon	0.2030
Phosphorus	0.0140
Sulphur	0.0226
Manganese	0.7530
Silicon	0.3700

THREADED GRIP BARS (MODIFIED BERRY STRAIN GAGE)

Johnson's elastic limit per square inch, pounds	20,216
Tensile strength per square inch, pounds	67,924
Elastic ratio, per cent	29.7
Elongation in 2 inches, per cent	31.5
Reduction of area, per cent	49.2

ROUGH TURNED GRIP BARS (FALL OF BEAM OBSERVED)

Yield point per square inch, pounds	43,540
Tensile strength per square inch, pounds	69,338
Elastic ratio, per cent	62.6
Elongation in 2 inches, per cent	31.1
Reduction of area, per cent	51.6

No apparent unusual effect was observed on the roof or bottom of the furnace, nor was any difficulty experienced at any time in making these heats. The average amount of magnesite, which was largely used for bottom repairs, was 660 pounds per heat.

On the assumption that in many plants it costs 2½ cents to compress and deliver 1,000 cubic feet of air at a pressure of 80 pounds, the average cost of compressed air can be figured at $1.55 per heat.

Unintentionally samples of slags were taken from only 14 of 15 heats atomized with steam and the determinations are summarized below:

	SiO_2	CaO	Al_2O_3	Mn_3O_4	P_2O_5	S
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Average....	12.75	52.83	2.54	5.54	1.56	0.06
Minimum...	11.37	50.77	1.25	5.08	1.44	0.03
Maximum..	14.42	55.19	3.58	6.02	1.70	0.11

	FeO	Fe_2O_3	MgO
	Per cent.	Per cent.	Per cent.
	14.66	2.46	5.02
	14.72	3.89	5.80
	14.97	3 25	5.32
	14.31	3.38	5.34
	15.66	4.68	4.66
	14.79	3.27	5.60
	16.73	4.22	5.68
	15.74	4.06	5.76
	15.97	2.90	7.71
	16.27	2.59	5.30
	14.37	3.53	6.18
	16.08	3.24	6.63
	15.44	4.06	5.89
	15.68	5.59	5.87
Average..	15.39	3.65	5.56

The physical and analytical tests showed the same degree of uniformity as observed in the metal on which air was used. The test bars were unannealed. The average results follow:

	Per Cent
Carbon	0.197
Phosphorus	0.0133
Sulphur	0.0239
Manganese	0.737
Silicon	0.357
Threaded Grip Bars (Modified Berry Strain Gage)	
Johnson's elastic limit per square inch, pounds..	19,821
Tensile strength per square inch, pounds	65,682
Elastic ratio, per cent	30.1
Elongation in 2 inches, per cent	30.4
Reduction of area, per cent	48.0
Rough Turned Grip Bars (Drop of Beam Observed)	
Yield point per square inch, pounds	42,764
Tensile strength per square inch, pounds	67,465
Elastic ratio, per cent	63.3
Elongation in 2 inches, per cent	31.1
Reduction of area, per cent	51.8

The condition of the furnace in every respect checked satisfactorily with the condition when air was used. The average amount of magnesite used for patching bottom, was 350 pounds per heat.

On the assumption that in many plants a cost of 14 2/5 cents is representative for generating 1,000 pounds of steam and delivering it at a gage pressure of 125 pounds, the average cost of steam used in atomizing each heat is $0.403.

Other Details of Tests

In making physical tests on the bars having threaded grips, and on which the modified Berry strain gage was used, a cross-head speed of 0.025 inch per minute was maintained until the apparent elastic limit was reached, after which the speed was increased to 0.78 inches per minute, and maintained until rupture occurred. The bars having plain turned grips were pulled at a cross-head speed of 0.59 inches per minute throughout.

No unusual characteristics of the metal when being poured were observed at any time. Purposely, all heats which were made under any undesirable or abnormal conditions were eliminated,

Table I.

Details of Heats Treated With Compressed Air

Consecutive heats from furnace since last repairs.	Weight charged, pounds.	Weight tapped, pounds.	Oxidation loss, per cent.	Temperature of surface of bath, 10 minutes before tap, degrees Fahr.	Oil consumed, gallons.	*Air consumption, cubic feet.	Time of heat, charge to tap, hours minutes.
275	57837	53150	8.10	3170	1182.0	62205	7: 45
277	57957	53040	8.48	3200	1158.2	57893	7: 20
278	58431	54000	7.59	3200	1201.2	65406	7: 31
281	58371	53675	8.04	3200	1312.2	61654	7: 45
282	57140	52630	7.89	3150	1202.8	64679	8: 00
283	58001	53263	8.16	3150	1205.6	60206	7: 35
284	58417	53840	7.83	3170	1150.3	65909	7: 35
285	57837	52890	8.55	3225	1161.1	62291	7: 28
286	57714	53462	7.36	3200	1226.2	57806	7: 40
287	57419	52955	7.77	3160	1215.1	67838	8: 05
288	57887	53132	8.19	3200	1211.0	63908	7: 50
307	57671	52683	8.65	3250	1236.3	62728	8: 05
308	57871	53352	7.89	3150	1299.8	60368	8: 30
309	57883	53300	7.91	3300	1192.6	58847	7: 55
310	57769	53320	7.69	3200	1206.5	59988	7: 50
Average	57880	53246	8.006	3195	1210.7	62115	7: 47

*Air consumption on a basis of free air at 14.7 pounds absolute and 70 degrees Fahr.

Table II.

Details of Heats Treated With Steam

Consecutive heats from furnace since last repairs.	Weight charged, pounds.	Weight tapped, pounds.	Oxidation loss, per cent.	Temperature of surface of bath, 10 minutes before tap, degrees Fahr.	Oil consumed, gallons.	Steam consumption, pounds.	Time of heat, charge to tap, hours minutes.
290	57890	53276	7.97	3200	1154.6	3146	7: 30
291	57273	52547	8.25	3200	1203.9	3308	8: 00
292	57299	53275	7.02	3175	1225.7	3669	7: 55
293	58057	53476	7.88	3150	1115.4	3078	7: 40
294	57986	52873	8.81	3200	1280.8	3375	7: 43
295	58322	53642	8.02	3175	1208.2	3254	7: 48
296	57227	53131	7.10	3200	1257.0	3567	8: 20
297	57592	53340	7.38	3075	1216.5	3592	7: 35
298	57449	53230	7.34	3175	1207.8	3378	7: 35
299	57874	53564	7.44	3150	1212.9	3820	8: 00
300	57750	53800	7.08	3050	1211.2	3939	8: 15
301	57303	53200	7.16	3200	1218.9	3757	7: 50
302	57863	53766	7.01	3175	1214.5	3448	7: 57
303	57660	52912	8.23	3150	1200.3	3682	8: 15
304	58370	54240	7.07	3250	1168.9	3389	7: 50
Average	57727	53351	7.58	3169	1206.4	3493	7: 52

as for example, any in which bottom troubles occurred. Observation of the furnace indicated the desired consistency of operations throughout the 30 heats tested. Observers were detailed to follow every operation throughout the 24-hours of each day, and all observations were carefully charted.

It had been the purpose to supplement this report by photomicrographs, but there could be no relation whatever established by examination of numerous etched unannealed specimens from these basic heats, under a microscope owned by the American Steel Foundries, and illustrations of the microscopical views would therefore be superfluous. Structures as observed were perfectly normal.

Comparative Summary of Results

A comparative summary of results is given below, all items being averages:

	Air.	Steam.
Weight charged per heat, pounds	57,880	57,727
Weight tapped per heat, pounds	53,246	53,351
Oxidation loss, per cent	8.006	7.58
Time per heat, charge to tap, hours and minutes	7:45	7:52
Oil used per heat, gallons	1210.7	1206.4
Amount of air used per heat, cubic feet	62,115	.....
Amount of steam used per heat, pounds	.....	3,493
Johnson's elastic limit (Berry gage), pounds	20,216	19,821
Yield point (drop of beam), pounds	43,540	42,764
Tensile strength, threaded grip, pounds	67,934	65,682
Tensile strength, plain grip, pounds	69,338	67,465
Elastic ratio (Berry gage), per cent	29.7	30.1
Elastic ratio (drop of beam), per cent	62.6	63.3
Elongation, threaded grip, per cent	31.5	30.4
Elongation, plain grip, per cent	31.1	31.1
Reduction of area, threaded grip, per cent	49.2	48.0
Reduction of area, plain grip, per cent	51.6	51.8
Carbon, per cent	0.203	0.197
Phosphorus, per cent	0.014	0.0133
Manganese, per cent	0.755	0.737
Silicon, per cent	0.37	0.351
Sulphur, per cent	0.0226	0.0239
Temperature of bath 10 minutes before tap, degrees Fahr.	3,195	3,169
Flue temperature, degrees Fahr	1,139	1,112

Careful analysis of the tests herein reported indicates that no relation can be drawn between the results with either superheated steam or compressed air as to the quality of the metal produced, time required for making heats, oil consumption, or temperatures secured.

Deductions

It seems possible that there is a relation as to effect on the furnace bottom in view of the fact that the average content of magnesium oxide in the slag on the heats treated with air averaged 42.6 per cent higher than in the case of steam-treated heats. The absorption of more magnesite into the slag on the air-treated heats as shown by the slag analysis, seems to tally with the increased amount of magnesite required for bottom patching on these heats.

Although the oxidation losses in the two groups of heats did not vary greatly, the advantage is in favor of steam-treated heats, in which there was apparently about 244 pounds of metal recovered per heat, which was lost when atomizing with air.

As to comparisons of final costs, each plant of necessity must form its own conclusions, arriving at them by the local costs for compressed air and superheated steam as well as by comparative data given. These data may not in every respect seem entirely conclusive to all students of open-hearth practice, but are believed to be more reliable for purposes of comparison than anything heretofore publicly reported. Characteristic local conditions must always be taken into consideration, and in respect to these, it is pertinent to emphasize that the 15 heats treated with air were manipulated by the same crews that handled the same number of heats treated with steam, and that there was no prejudice on the part of furnacemen or observers conducting the tests, and abundant opportunity for the closest supervision.

Since the cost of delivering the required amount of air would be invariably higher than that entailed by the delivery of the required amount of steam superheated by any such economical means as is here reported, there would seem to be a considerable commercial advantage in employing superheated

steam as an atomizing agent in basic open-hearth practice, with no loss to the quality of the product.

There will be observed a striking divergence between the yield point determined by the drop of the beam and the apparent elastic limit as determined by the use of the modified Berry strain gage and the method described in J. B. Johnson's "Materials of Construction." This divergence of results emphasizes the necessity for defining exactly not only what is meant by the term *elastic limit,* but the means employed for ascertaining such limit. Comparisons are absolutely valueless without information on these points, as fittingly observed by T. D. Lynch in his paper read before the American Society for Testing Materials this year.

R. A. BULL,

SUPERVISOR OF BASIC ATOMIZATION TESTS FOR COMMITTEE ON STEEL FOUNDRY STANDARDS

Discussion

THE CHAIRMAN, MR. R. A. BULL:—This report is not a complete, but a partial one. I will say, in this connection, that it may have been somewhat out of the proper technical function of the committee on steel foundry standards to undertake the test it has undertaken. The reason for that was that it was the only committee of the Association relating to steel foundry work, with the exception of the Committee on Specifications for Steel Castings, so there are no standards recommended, and will be none, as a result of the committee's report. The results of the investigation are simply given for information. It was suggested that the matter of determining the relative advantages and disadvantages of atomizing fuel oil in open-hearth practice might be investigated. Melters have been very much divided on that subject for a great many years and it has been, in a good many plants, a pretty difficult matter to get any intelligent comparison. The circumstances were such, not very long ago, as to enable some of us to undertake such an investigation and the results obtained up to date are given in the report. In making these tests, a good many interesting things were observed and there may be some items of useful

information entirely apart from the atomizing data which it would be well to make a record of. For one thing, the divergence in the yield point taken from the drop of the beam and the elastic limit, determined by the modified Berry strain-gage according to the method devised by Mr. Johnson is very marked and may serve to keep some people from getting into trouble in agreeing to supply steel with an elastic limit according to the Berry-Johnson method, which may be impossible to attain. Mr. Shoemaker, would you like to supplement this?

MR. DUDLEY SHOEMAKER:—I do not think many of us realize the amount of work involved in getting up these figures. I have been chairman of this committee which decided, about five months ago, to make a series of tests on the basic furnace in one of the plants and follow them up by a test at Indiana Harbor, Ind. I fell down on my end of the test, but I want to say that Mr. Bull has made a real contribution to the knowledge we all seek in regard to running the open-hearth furnace with oil. It is of interest, of course, to those who have oil-burning open-hearths. I want to congratulate Mr. Bull on these results, which I believe are conclusive, and I think these tests are flawless and will stand any kind of criticism anybody wants to make. You can actually bank on these results as being accurate all the way through.

DISCUSSION BY CORRESPONDENCE

(From letter Nov. 2, 1915, by Dr. H. W. Gillett, alloy chemist, United States Bureau of Mines.)

You give the temperatures of the bath in the open-hearth furnace 10 minutes before the tap.

We are interested in the determination of the temperatures of molten metals, and I find no details as to how the measurements were made. I assume that an optical or radiation pyrometer was used. Was this sighted on the molten metal or the slag, or into a closed-end tube immersed in the bath? If the latter, what sort of a tube was used? Were any corrections necessary for deviation from black body radiation?

(From letter Nov. 11, 1915, by Mr. R. A. Bull.)

Possibly you may not have seen the complete report, but only an abstract of it. As to the assumption that an optical or radiation pyrometer was used I will call your attention to

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the last paragraph on page 3 of the official copy of the report in which this statement appears:

"The temperature of the bath in the furnace was taken by a Seimatco optical pyrometer."

In basic open-hearth practice with a stationary furnace it is, as you doubtless know, impracticable to remove the slag for observation of the metal, and the pyrometer was sighted on the slag itself in all cases. It would have been more scientific to have employed a closed-end tube immersed in the bath, but you can appreciate that there would be considerable difficulty in practice in the employment of this method. It was thought that by taking all observations on the slag in the same way, relative results would be obtained which would serve the particular purpose intended in making these tests.

There were no corrections made from the readings of the scale. You probably know that the Seimatco optical pyrometer is used in connection with two different scales, one for taking temperatures of objects surrounded by heated walls, and the other designed by Dr. G. A. Shook, for determining temperatures of materials in the open. It was assumed that the scale for determining temperatures in the furnace required no correction by us for deviation from black body radiation, and that the manufacturers of the pyrometer had made the necessary corrections in designing the scale.

(From letter Nov. 17, 1915, by Dr. H. W. Gillett, alloy chemist, United States Bureau of Mines.)

I had not seen the official report of the committee, and if the abstract I saw contained the information on the type of pyrometer used I must have overlooked it.

I am not familiar with steel practice, our pyrometer work being on brass and bronze, but unless there was enough fume in the furnace to interfere with the readings, it would appear that the optical pyrometer you used should give correct readings, and should be as satisfactory as any type available.

(From letter Nov. 4, 1915, by Mr. Herbert F. Miller, Jr., metallurgical engineer.)

While great pains were evidently made to insure data worthy to be called reliable, I regret that the experiments did not go a few steps further and cause an entire reversal of the conclusions that were drawn from the data found, namely, a preference for steam over air. It will be found if experiments are made that the seeming superiority of the steam is a result of the higher temperature of the oil which was given by the superheated steam over the cold oil and cold air.

Now, if the compressed air line is connected with the superheating coil and the steam shut off the following results will be obtained:

1.—A lower pressure of air will be used for atomizing.
2.—Less oil per ton of steel produced.
3.—A much lower stack temperature.
4.—An increased output per hour.

To carry out to the end let another line be laid with the superheating coil and used for superheating the oil. This can be safely done. The result of this double change will mean a saving in gallons per ton of steel and a lowering of all costs. The superheating of the oil will still further decrease the necessary consumption of compressed air if it does not eliminate it altogether.

With proper port construction the use of air or steam may be dispensed with and advantage taken of the property of oil of flashing into a gas and a flame superior to natural gas obtained.

The data showing most clearly that there was a great fuel waste is that recording the stack temperatures which are 500 to 600 degrees Fahr. too high. This is due to the forced draft created by the high pressure of air or steam used.

With equal treatment it will be found air is much superior to steam for the purpose of atomizing.

(From letter Nov. 11, 1915, by Mr. R. A. Bull.)

It will be very much appreciated if you will be good enough to submit reports of tests which have led to your conclusions. There are many who prefer comparison of actual records to acceptance of general statements or conclusions. In this connection I beg to point out that the deductions made at the conclusion of the report of the committee are cautiously stated, and it was borne in mind that difficulties are encountered when one has the boldness to make positive statements without a proper basis of scientific facts. You will probably have noted that the report submitted refers to basic practice, and that this statement appears in the conclusion: "These data may not in every respect seem conclusive to all students of open-hearth practice, but are believed to be more reliable for purposes of comparison than anything heretofore publicly reported."

(From letter Nov. 15, 1915, by Mr. Herbert F. Miller, Jr., metallurgical engineer.)

I think that the conclusions drawn from the data gathered were the only ones that could be drawn correctly by the

A. F. A. Committee. However, my mind runs in a way that asks *why* is this difference in the action of air and steam shown in favor of the steam for purposes of atomizing when one might possibly have expected a conclusion in favor of air?

May I try now to make good my boldness to make positive statements by submitting some scientific facts and some experiments and measurements I have taken?

First, the application of steam or water to combustion is an endothermic reaction because it involves one of two ways or both of utilizing heat of combustion. First, the raising of the steam from initial temperature to the flame temperature; second, the possible reaction between oil and steam in breaking up the steam into free hydrogen and oxygen. The heat required to disassociate elements is always greater than heat of association. These facts being so, why should steam have a favorable action? What was the good thing about the steam that aided a resulting conclusion favorable to its use? The only helpful factor was its sensible heat from the superheating oil. Although the report does not state so, the action of the committee in assenting to the superheating indicates they had the above facts in mind in some form.

Next, what was the trouble with the air that made it seem less desirable to use than superheated steam? Air is used for combustion in all commercial activities on a large scale.

Obviously, the only detrimental factor was that the air was at atmospheric temperatures so that the nitrogen had to be raised from say 70 degrees Fahr. to the flame temperature of say 2,500 degrees Cent., and furthermore, a large portion of the oil was burned with the cold air blown in to atomize it, whereas with the steam the oil was burned nearly all by the superheated air from the checkers; therefore, a slightly lower flame temperature was obtained by using cold air for atomizing.

The scientific fact of combustion is that as the initial temperature of combustible and source of combustion is raised, in like manner the flame temperature is raised. For example, if cold air and cold oil have a flame temperature of 1,800 degrees Cent. and the air is raised to 1,000 degrees Cent.; the new flame temperature will approximate 2,800 degrees Cent.

Therefore, the thing that the compressed air lacked that the steam had was the superheating.

In regard to using fuel oil without atomizing with steam or air. It is a fact that fuel oil flashes into a gas at comparatively low temperatures. With this in mind I have introduced into the port a 1-inch pipe with holes ⅛-inch in diameter, drilled in it, and produced a flame as good as that from natural gas

I was using at the time, and this without using any steam or air for atomizing. The type of port, however, differs from that ordinarily used and is much superior to it in my judgment.

(Sketch of port submitted with letter.)

In regard to stack temperatures, I have made repeated measurements at the Verona Steel Castings Co. (basic open-hearth furnaces) and there the stack temperatures run 560 degrees Fahr. to 680 degrees Fahr. The draft is created by stack and fuel is natural gas. Local conditions usually are not a type and results vary in each plant.

(From letter Nov. 24, 1915, by Mr. R. A. Bull.)

Your last letter mainly has reference to the phenomena of combustion, and these naturally suggest themselves following any claim for superior ability of either of the gases employed for atomizing. Permit me to point out that no such claim has been made in the report. There is a cautiously stated deduction that "it seems possible that there is a relation as to effect on a furnace bottom", etc., which can exist regardless of the relative atomizing efficiency considered apart from other characteristics in open-hearth application. It is also shown that, in the two groups of heats observed, the average of the determined oxidation losses are in favor of the steam-treated heats. The significant conclusion is that "there would seem to be a considerable *commercial* advantage in basic open-hearth practice, with no loss to the quality of the product."

In the quotation above, but not in the report, I have, as you see, emphasized the word "commercial". It has not been claimed that steam has superior power to produce a hotter flame. The point which you emphasize is that the efficiency of the flame, other conditions being identical, is governed proportionately as the temperatures of the agencies for producing it are preheated. I confess that I have made no exhaustive study of thermo-chemistry, although I have a slight knowledge of the chemical changes that occur in combustion. Such knowledge of the subject as I have, does not enable me to refute your argument just cited, but my information as to the actual results obtained in open-hearth practice shows no net advantage favoring high degrees of superheat for either steam or air, or a high temperature for fuel oil, even when the latter is maintained below the volatilizing point, in open-hearth operation. I am of the opinion that, in such practice, which is what we are alone considering, conservative temperatures are to be preferred. Several members of our committee, who had extensively experimented with high degrees of superheat experienced diffi-

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culties, and in pre-determining the approximate amount of superheat for steam for these tests, which, as stated, averaged 140 degrees Fahr., the main consideration was simply the elimination of moisture.

The thing to be seriously taken into account in analyzing the report is the excessive cost of compressing air as compared with the expense of making steam. Assuming, as one can without contradicting any positive statement in the report (notwithstanding the attention directed to some circumsantial, but not fully convincing evidence), that air and steam have equal ability, under the same conditions, for atomizing oil in open-hearth practice, we still have with us the very important commercial factor of relative costs of the two gases.

If, now, it can be shown that, by high degrees of superheat air has advantages over steam in open-hearth practice that more than compensate for the higher initial cost of the former, the only real conclusion in the report will be refuted, and the compiler of the report, together with those who collaborated in pre-determining the conditions of the tests and in making the same, will feel you have performed a highly valuable service, and that they have done so to the extent of bringing out this information in the discussion.

From the above statement it will, I think, be plain that, relatively low temperatures of air, steam and oil were provided purposely, and not through disregard of the effect of temperature. Your strong predilection for high temperature evidently based on results you have actually obtained, invites my reference to some results along contrary lines for mutual comparison. Several careful and experienced observers, well known to the writer, have positively concluded that steam or air with more than 200 degrees Fahr. of superheat produces a very hot flame which, despite all efforts to control it, quickly attacks the roof of the furnace. This is a practical confirmation in part of the accepted theory that the hotter the agencies for producing combustion, the hotter the flame resulting. My belief is that there can be economically utilized in open-hearth practice a very limited amount of temperature from pre-heating. Certainly the oil must be hot enough to flow with maximum velocity and uniformity; likewise, there should be no moisture in either steam or air for the best atomizing results. If physical conditions, such as insulation, location and demand upon pipe lines were, as in some cases, they may be favorable to superheating the air, I confess my preference would be to supply sufficient heat to eliminate even the small amount of moisture which passes through the air lines and is not entirely eliminated by means of effective and carefully placed

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traps. The amount of moisture in any compressed air system is, as you of course know, governed partly by the humidity of the atmosphere. The weather conditions were extremely favorable in every respect when the tests reported were made. I may be wrong in my opinion that, if the small amount of moisture in the air line at the burner had been entirely removed, there would not have been sufficiently greater efficiency to have more than compensated for the slightly poorer showing in the air-treated heats; but I feel quite sure that, in no such case, would there have been enough advantage in the air-treated heats to compensate for the higher initial cost of the air. One must regret that, in view of any question raised, the local conditions did not favor as much superheat for the air as was supplied for the steam, but in view of the test reports, and the data supplied in the resulting discussion, the conclusion still appears to me as logical.

Concerning the temperature of the oil itself, the experience of many, including the writer, is that the flame is intermittent, therefore inefficient, when the temperature is higher than 150 degrees Fahr. Such oil has already been subjected to higher temperatures than that previously in distillation, so that the intermittent flow cannot be accounted for by partial volatilization. The writer believes the difficulty lies in the handling of the hotter oil with the ordinary type of pump.

Your comments concerning the use of oil as fuel without any atomizing agent, are interesting enough to warrant, at another time, an extended discussion on this point alone, especially since its consideration does not directly affect any question raised in the report. We all know that we may vaporize oil by applying the proper temperature, and that the resulting gases are highly combustible. The satisfactory control and economical application of the flame so produced for open-hearth furnaces, are problems in themselves which have been found by many very difficult to solve. You should be congratulated upon your successes in this direction and tendered thanks for the information as to port construction for this application.

THE CHAIRMAN:—Are there any remarks on this report? Did you have in mind, Mr. Shoemaker, to invite any suggestions at this time toward any further matter that might be taken up by your committee?

MR. DUDLEY SHOEMAKER:—As to the standardization of nozzle brick, some progress was made. Standards were prepared and sent around to all the steel foundries in the country.

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Of 65 foundries that were using equipment on which the standard nozzle could be employed, 40 sent word to the committee that they would give the thing a trial or would adopt it. Progress has necessarily been slow and up to a few months ago was very poor. Most foundries had large stocks of their own design. I think real good was done to a certain extent. Most of the brick manufacturing plants now have this A. F. A. nozzle on hand, specially made for steel foundry service. Like other standards already adopted, it was a very hard matter to come to a conclusion to suit everybody. That is going to be the trouble with everything else taken up along these lines. Everybody has to help in any standard that is going to be put through, and there has to be very close co-operation. The committee will be glad to do any work the members would recommend along lines they will co-operate in, but unless some good can be done, it seems to me that it is useless to continue the committee. I think we ought to have some definite aim to accomplish.

THE CHAIRMAN:—It was my idea to bring up that one point to ascertain if there would be something the committee could profitably do. I think the committee, under the leadership of Mr. Shoemaker, did a great deal of valuable work on that nozzle proposition. I doubt, however, whether many of us are in position to report about the suitability of that nozzle from our practical experience. As Mr. Shoemaker stated, a good many of us were pretty well stocked up, and during the last year we did not use many nozzles, and I know that was true in the case of my own company. It may be, however, that there are those present who have had considerable experience with the standard nozzle and can enlighten the committee on that point. I will wait at this juncture to invite any who have had any experience, to relate it. To start with, has there been any objection raised?

MR. W. A. JANSSEN:—I cannot tell anything about objections.

THE CHAIRMAN:—Well, if you can say anything good for it, we will be glad to have it. I think if this committee never did develop another thing for the American Foundrymen's Association with special reference to the steel men, they have

certainly done a world of good in the particular report and action on the standardization of nozzles. I think that almost every steel foundryman will bear me out in the trials and tribulations we have had with various nozzles from different brick makers or even from a single brick maker. However, those people are not always to be censured, for many steel founders only order in small quantities, everyone having his own particular notion as to what has been best adapted to his needs. The nozzle manufacturers were unable to give it the attention they could if they had had a standard product. From our experience we have adopted the flat-faced nozzle as recommended by this committee, and we have yet to notice any defect in the nozzle, and my argument in the past has always been that I did not care what the cost of the nozzle was if they would assure a uniform product, and we certainly have been able to obtain a uniform product and cannot help but feel that it is due to standardizing and to the co-operation of the brickmaker with the foundryman in producing a uniform product.

MR. DUDLEY SHOEMAKER:—In regard to the nozzle proposition, I would like to say that, while the foundries have not used a great number of nozzles, the greatest good it did was to bring to the attention of all brickmakers the deplorable condition in which the product was being sent to some steel founders, and all of them are making better nozzles than before. The matter of particular design is capable of many changes; there may be or may not have been a great change for the better in adopting the standard, but we do know that they are making nozzles better; in that direction the committee has done fairly good work, I believe. Whether or not there is anything else to take hold of, I don't know.

THE CHAIRMAN:—In that connection I will say that some months ago I visited a plant of a crucible company, and knowing the fact, that the Association had adopted the standard nozzle, the manager was very desirous that we take similar action in regard to stoppers. You remember that we had some discussion on that one thing last year, and it was thought that the matter of stoppers was relatively insignificant as compared with nozzles. This gentleman, however, assured me that he

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made some 62 designs of stoppers for steel foundry work. I was astonished at that fact, and he said that the stopper people would be very grateful for anything we might do to standardize designs and arrive at a reasonably small number of models. Now, it is quite possible that any action the committee might take on this line might result more to the benefit of the crucible manufacturers than ourselves, but I believe this thing always holds true, that if we can adapt ourselves to the manufacturer's point of view, we can buy our commodities cheaper than otherwise. We know how that is when we make castings from different patterns and have to change our patterns. Has anyone any suggestion as to any further activity on the part of the committee?

MR. W. A. JANSSEN:—I believe the suggestion you just made is very well taken. It was only yesterday that I was discussing the stopper proposition with a foundryman from one of the Canadian plants, and he knew of the practice at our particular plant and was telling me of the type he was using. He is using the screw stopper and he had some very good reasons, or what appeared, at least, to be good reasons, to him, for not wanting to use the pin, and yet we all know that a great percentage of foundrymen in this country use the old type with the Swedish iron or mild steel pin, and the matter of the different shapes and contours which we have to contend with in establishing a standard nozzle. I believe, just as you do, that that is a matter which might be referred to this committee. Although the manufacturer is really the man that is benefited, apparently, nevertheless I believe too that some people, some of the foundrymen who have particular hobbies and insist on a particular stopper, would really be benefited by being enlightened, and I do not believe it would be so very arduous for the committee to proceed along those lines.

THE CHAIRMAN:—Do you care to make that as a motion?

MR. W. A. JANSSEN:—Possibly we'd better wait for further discussion; somebody might have something of greater importance.

THE CHAIRMAN:—We will be glad to hear from anyone on this subject.

MR. W. A. JANSSEN:—There being no further recommen-

dations, I present a motion that the Committee on Steel Foundry Standards investigate the various designs of stoppers with a view of standardization.

MR. G. E. JONES:—I second that motion, but would like to say that it seems to me, if I remember correctly, last year the committee had blue prints made of those stoppers and passed them around, and as I remember it, that committee was instructed, or requested, to investigate the matter among the foundrymen and find out as nearly as they could, who would agree to the standards they were recommending. I did not see any further reports from that committee and don't know whether anything further has been done.

THE CHAIRMAN:—Mr. Shoemaker, is your recollection clear about that?

MR. DUDLEY SHOEMAKER:—I reported that out of 65, 40 replied that they would either adopt it or give it a trial. It was not thought advisable to publish the names of these companies, but everybody was supplied with prints showing the standard and told they would be able to buy them from the leading manufacturers of nozzles. All of the manufacturers of nozzles were supplied with prints showing the regular standards of the Association, and all of them are making better nozzles than they did from other designs, because they understand what the requirements are. In regard to the stopper proposition, the reason it was not followed through at the time was because the stopper had some pretty good qualities and there seemed to be no crying need of any great betterment of quality. The matter of changing the design was one that would benefit, I believe, the manufacturer more than it would the steel foundryman; at the same time it would aid quick deliveries and might be of benefit in that way. It is something that could be easily accomplished and I think we should get a suggestion from the manufacturers first, they are really the ones that are proposing the thing to us.

THE CHAIRMAN:—Are there any further remarks? The motion is, gentlemen, that the committee on standards be instructed to investigate the design of the stopper head with the idea of arriving at a standard design.

The motion was adopted.

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Report of A. F. A. Committee on Standard Specifications for Steel Castings

Your committee on Specifications for Steel Castings appointed to work with a similar committee from the American Society for Testing Materials, has the following to report:

The committee has limited its activities to recommending certain modifications of specifications for steel castings as last revised by the American Society for Testing Materials. These modifications have been presented to the proper committee of the Testing Society, which promises to pass upon them in time for a possible agreement of the two committees before the next convention of the A. S. T. M. The modifications proposed are shown in italicized print immediately following the sections suggested for revision in the subjoined complete specifications as adopted and revised by the A. S. T. M., and your committee will gladly receive criticisms and suggestions.

W. G. Nichols, originally a member of this committee, recently found it advisable to withdraw without prejudice toward the views held by the other members concerning the modifications proposed.

W. C. HAMILTON, CHAIRMAN.
S. R. ROBINSON.
R. A. BULL.
Committee on Standard Specifications for Steel Castings.

Reasons for Proposed Modifications in Steel Casting Specifications Adopted by American Society for Testing Materials

It would be difficult to specify a certain heat treatment for steel castings, as the name, owing to the increasing use of this product, now includes a great number of designs made from a material which may vary to a great extent in its qualities, especially as related to heat treatment. **Heat Treatment**

To refine the microstructure of a steel casting we know that the casting must have cooled below a certain critical point before it may be heated for the purpose of refining the grain. However, there are designs, which, if allowed to become cold from the casting temperature before being heat-treated, will be fractured by the cooling strains. These cooling strains are arrested when the casting is reheated to the proper temperature before it has become cold from the casting temperature, but after it has cooled below its critical temperature. This critical temperature varies with different compositions, but so long as the heat treatment has refined the grain of the steel there should be no reason for specifying to what temperature the casting shall have cooled before it is given a heat treatment.

Again there are castings which are better fitted for service if they are cooled very quickly rather than slowly, while other castings must be cooled very slowly from the annealing temperature in order to meet requirements. It is known that quick cooling from the proper temperature will give a finer microstructure to ordinary steel than will slow cooling, also that the elastic limit of the steel will be higher if it is cooled quickly. On the other hand, quick cooling reduces the ductility

of the steel and on certain designs will place strains in the castings which would not result from slow cooling. Hence we believe that the heat treatment of steel castings should be decided by the manufacturer, but be subject to the approval of the purchaser or his representative.

Chemical Composition

The specifications of the American Society for Testing Materials, allowing for the 20 per cent excess under Class A, require a phosphorus content not over 0.072 per cent with no sulphur limit. Under Class B the limit is 0.06 per cent for both phosphorus and sulphur, with the exception of material for railway rolling stock, for which the phosphorus and sulphur limits are both 0.050 per cent.

We believe that these limits should be made positive with no excess allowed and that these proposed limits of 0.065 per cent phosphorus for Class A castings and 0.055 per cent phosphorus and 0.06 per cent sulphur for Class B are safe ones for all purposes.

Ladle Analyses

As silicon is important in steel castings, we believe that this element should be included in the analyses.

Tension Tests

The yield points given in pounds per square inch in the specifications of the American Society for Testing Materials are on a basis of 45 per cent of the tensile strengths. However, a test bar in the soft grade giving 68,000 pounds tensile strength should have more than 27,000 pounds yield point, and by the proposed change to 45 per cent of the tensile strength a yield point of 30,400 would be required. This is an advantage to the purchaser, but a similar rule should apply to the low limit for the elongation. Under the specifications of the American Society for Testing Materials, the above test bar, having 68,000 pounds tensile strength, would require 22 per cent elongation, while a bar having 70,000 pounds tensile strength would require only 18 per cent elongation.

In the proposed method of obtaining the elongation by dividing 1,400,000 by the tensile strength, the requirements for

tensile strengths of 60,000, 70,000 and 80,000 are raised from 15, 18 and 22 per cent, respectively, to 17.5, 20 and 23.3 per cent, but as the tensile strengths increase, the required elongations decrease as is known to be the case in actual results. Hence we believe that both the manufacturer and the purchaser will be benefited by these modifications.

Alternate Tests to Destruction

Especially when small castings are being made it is not practical to keep together the castings from one heat and anneal them at the same time, so we believe that in making the above tests the castings selected should not represent both one heat and one annealing charge, but either one as the inspector may desire.

Test Specimens

The test lugs are recommended for the convenience of the purchaser, as in most cases all gates and risers have been removed before a casting has been annealed and without the test lugs or test bars the inspector has no quick method of determining the character of the annealing.

While the standard threaded test bar for tensile tests will give the best physical results, on account of its giving a straighter pull, still the expense of preparing them is much greater unless the proper equipment is at hand. The turned grips will not improve the physical results and are more easily prepared, so in case the manufacturer is willing to take a chance with these turned grips, we believe that he should be allowed to do so.

Your committee realizes that there will be differences of opinion in regard to specifications, both between this association and the American Society for Testing Materials, and also between members of this association, and it will gladly receive any criticisms or suggestions that may be offered concerning the modifications already proposed or others that may seem desirable.

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A. S. T. M. Standard Specifications for Steel Castings

Special Designation A27-14

ADOPTED 1901, REVISED 1905, 1912, 1913, 1914.

1. These specifications cover two classes of castings, namely:

Classes

Class A, ordinary castings for which no physical requirements are specified.

Class B, castings for which physical requirements are specified. These are of three grades: hard, medium and soft.

2. (*a*) Patterns shall be made so that sufficient finish is allowed to provide for all variations in shrinkage.

Patterns

(*b*) Patterns shall be painted three colors to represent metal, cores and finish surfaces. It is recommended that core prints shall be painted black and finished surfaces red.

Basis of Purchase

3. The purchaser shall indicate his intention to substitute the test to destruction specified in Section 11 for the tension and bend tests, and shall designate the patterns from which castings for this test shall be made.

I. MANUFACTURE

Process

4. The steel may be made by the open-hearth, crucible or any other process approved by the purchaser.

5. (*a*) Class A castings need not be annealed unless so specified.

Heat treatment

(*b*) Class B castings shall be allowed to become cold. They shall then be uniformly reheated to the proper temperature to refine the grain (a group thus reheated being known as an "annealing charge"), and allowed to cool uniformly and slowly. If, in the opinion of the purchaser or his representative, a casting is not properly annealed, he may at his option require the casting to be re-annealed.

> 5. (*b*) *Class B castings shall be properly annealed. If, in the opinion of the purchaser or his representative, a casting is not properly annealed, he may at his option require the castings to be re-annealed.*

II. CHEMICAL PROPERTIES AND TESTS

6. The castings shall conform to the following requirements as to chemical composition:

	Class A	Class B
Carbon	not over 0.30 per cent	....
Phosphorus	not over 0.06 per cent	not over 0.05 per cent
Sulphur	....	not over 0.05 per cent

Chemical composition

	Per Cent.	*Per Cent.*
Carbon	*not over* 0.30	.....
Phosphorus	*not over* 0.065	*not over* 0.055
Sulphur	.....	*not over* 0.060

7. An analysis to determine the percentages of carbon, manganese, phosphorus and sulphur shall be made by the manufacturer from a test ingot taken during the pouring of each melt, a copy of which shall be given to the purchaser or his representative. This analysis shall conform to the requirements specified in Section 6. Drillings for analysis shall be taken not less than ¼ inch beneath the surface of the test ingot.

Ladle analyses

Add "silicon" after "manganese" to list of elements to be analyzed.

8. (*a*) Analyses of Class A castings may be made by the purchaser, in which case an excess of 20 per cent above the requirement as to phosphorus specified in Section 6 shall be allowed. Drillings for analysis shall be taken not less than ¼-inch beneath the surface.

(*b*) Analyses of Class B castings may be made by the purchaser from a broken tension or bend test specimen, in which case an excess of 20 per cent above the requirements as to phosphorus and sulphur specified in Section 6 shall be allowed. Drillings for analysis shall be taken not less than ¼-inch beneath the surface.

Check analyses

Omit Sections 8 a and b entirely.

III. PHYSICAL PROPERTIES AND TESTS

(For Class B Castings Only)

9. (*a*) The castings shall conform to the following minimum requirements as to tensile properties:

	Hard.	Medium.	Soft.
Tensile strength, lb. per sq. in.	80,000	70,000	60,000
Yield point, lb. per sq. in.	36,000	31,500	27,000
Elongation in 2 in. per cent	15	18	22
Reduction of area, per cent	20	25	30

Tension tests

Specify that yield point shall equal 45 per cent of tensile strength per square inch, and that the percentage of elongation in 2 inches shall equal 1,400,000 divided by the tensile strength per square inch.

(*b*). The yield point shall be determined by the drop of the beam of the testing machine.

Bend tests

10. (*a*). The test specimen for soft castings shall bend cold through 120 degrees, and for medium castings through 90 degrees around a 1-inch pin, without cracking on the outside of the bent portion.

(*b*) Hard castings shall not be subject to bend test requirements.

Alternative tests to destruction

11. In the case of small or unimportant castings, a test to destruction on three castings from a lot may be substituted for the tension and bend tests. This test shall show the material to be ductile, free from injurious defects, and suitable for the purpose intended. A lot shall consist of all castings from one melt, in the same annealing charge.

Omit from the first sentence the words "or unimportant".

Change last sentence to read: "A lot shall consist of all castings from one melt or in the same annealing charge".

Test specimens

12. (*a*) Sufficient test bars, from which the test specimens required in Section 13 (*a*) may be selected, shall be attached to castings weighing 500 pounds or over, when the design of the castings will permit. If the castings weigh less than 500 pounds, or are of such a design that test bars cannot be attached, two test bars shall be cast to represent each melt; or the quality of the castings shall be determined by tests to destruction as specified in Section 11. All test bars shall be annealed with the castings they represent.

Add to section the following: When desired by the purchaser suitable test lugs shall be cast on castings which do not have test bars attached so that the inspector may judge the annealing.

(*b*) The manufacturer and purchaser shall agree whether test bars can be attached to castings, on the location of the bars on the castings, on the castings to which bars are to be attached, and on the method of casting unattached bars.

(*c*) Tension test specimens shall be of the form and dimensions shown in Fig. 1. Bend test specimens shall be machined to 1 by ½-inch in section with corners rounded to a radius not over 1/16 inch.

Add to first sentence of (c): "or have turned grips at the option of the manufacturer".

Number of tests

13. (*a*) One tension and one bend test shall be made from each annealing charge. If more than one melt is represented in an annealing charge, one tension and one bend test shall be made from each melt.

(*b*) If any test specimen shows defective machining or develops flaws, it may be discarded; in which case the manufacturer and the purchaser or his representative shall agree upon the selection of another specimen in its stead.

(*c*) If the percentage of elongation of any tension test specimen is less than that specified in Section 9 (*a*) and any part of the fracture is more than ¾-inch from the center of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

IV. WORKMANSHIP AND FINISH

Workmanship

14. The castings shall substantially conform to the sizes and shapes of the patterns, and shall be made in a workmanlike manner.

Finish

15. (*a*) The castings shall be free from injurious defects.

(*b*) Minor defects which do not impair the strength of the castings may, with the approval of the purchaser or his representative, be welded by an approved process. The defects shall first be cleaned out to solid metal; and after welding the castings shall be annealed, if specified by the purchaser or his representative.

(*c*) The castings offered for inspection shall not be painted or covered with any substance that will hide defects, nor rusted to such an extent as to hide defects.

V. INSPECTION AND REJECTION

Inspection

16. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed to all parts of the manufacturer's works which concern the manufacture of the castings ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the castings are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of the manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection

17. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 8 shall be reported within five working days from the receipt of samples.

(*b*) Castings which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing

18. Samples tested in accordance with Section 8, which represents rejected castings, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

VI. SPECIAL REQUIREMENTS FOR CASTINGS FOR SHIPS

Castings for ships

19. In addition to the preceeding requirements, castings for ships, when so specified, shall conform to the following requirements:

Heat treatment

20. All castings shall be annealed.

Number of tests

21. (*a*) One tension and one bend test shall be made from each of the following castings: stern frames, stern posts, twin-screw spectacle frames, propeller shaft brackets, rudders, steering quadrants, tillers, stems, anchors, and other castings when specified.

(*b*) When a casting is made from more than one melt, four tension and four bend tests shall be made from each casting.

Percussion tests

22. (*a*) A percussion test shall be made on each of the following castings: stern frames, stern posts, twin-screw spectacle frames, propeller shaft brackets, rudders, steering quadrants, tillers, stems, anchors, and other castings when specified.

(*b*) For this test, the casting shall be suspended by chains and hammered all over with a hammer of a weight approved by the purchaser or his representative. If cracks, flaws, defects, or weakness appear after such treatment, the casting will be rejected.

VII. SPECIAL REQUIREMENTS FOR CASTINGS FOR RAILWAY ROLLING STOCK

Castings for railway rolling stock

23. Castings for railway rolling stock, when so specified, shall conform to the requirements for Class B castings, Sections 1 to 18, inclusive, except that check analyses made in accordance with Section 8 (*b*) shall conform to the requirements as to phosphorus and sulphur specified in Section 6.

Omit entirely if changes in Section 6 are made.

(For Fig. 1 see Detail of Bar With Threaded Grip, Page 141, A. S. T. M. 1914 Year Book.)

Discussion—Standard Specifications for Steel Castings

MR. H. E. FIELD:—I might explain for those who are not familiar with the situation, that the specifications, which are in use at present, were adopted by the American Society for Testing Materials, after consulting with a committee which represented 80 per cent of the steel foundries of the country. I believe if we tamper with them, we will furnish the steel founders with a stricter set of specifications than they are now using. I feel that while the present specifications may not be all that is to be desired, they are very much better than they will be, if opened up again. The committee which handled this matter was made up of a committee consisting of manufacturers, engineers and members of the Steel Founders' Society of America. The Steel Founders' Society of America I suppose represents about 80 per cent of the makers of steel castings in the country, so I would hesitate before attempting to change the specifications unless you want stricter specifications put around the foundries. This association not only represents makers of electric steel who have no trouble meeting these specifications at all, the acid steel founders, who should have no trouble, but it also represents a large percentage of the men who make bessemer steel or converter steel. I am told, by makers of converter steel, that these specifications are just about as strict as they want to stand for. Taking everything into consideration, I move that we table the recommendation.

The motion was seconded.

THE CHAIRMAN, MR. R. A. BULL:—That motion is open for discussion. The chair would like to voice his opinion that the motion is ill-advised. I think that there are a good many steel founders present who have no connection with the Steel Founders' Society. I believe, too, that the Testing Society welcomes co-operation with this and other organizations in the revision, or preparation of various specifications. The gentleman who has just spoken, Mr. Field, undoubtedly has given a good deal of thought to this matter and is very

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well informed concerning it, and he does not claim that the specifications are perfect, but his point seems to be that if we tamper with the specifications as they are, we may get our foot into it, may get into difficulties. Now I don't know just what basis Mr. Field has for making that suggestion, but I cannot help feeling, from the very kindly correspondence with members of the Testing Society, of which I have personal knowledge, that he is misinformed concerning the Testing Society's attitude. It probably would be pertinent to refer to the fact that there is considerable "give and take" in the modifications that are suggested, and a number of items are referred to which would certainly strike the Testing Society's committee as working to the advantage of the consumer. It seems to me that both organizations are big enough, and that the relations between the producer and consumer are getting close enough, to rather guarantee a ground on which we may both meet, which will be more satisfactory to all concerned than present conditions. I would like to have others express their views on this matter. Are you ready for the question? All in favor of tabling the proposed modifications of the committee on specifications will indicate by saying "aye".

The motion was carried.

THE CHAIRMAN:—Now gentlemen, what is your pleasure in regard to continuing such a committee? It would obviously be out of place for the committee to remain as a committee of the association with this action taken on its report. Unless there is some objection, it will be assumed that the committee may be discontinued. Is that the pleasure of the session? This is an important matter and you ought to speak your minds about it, one way or the other.

MR. H. COLE ESTEP:—I would suggest that the question of continuing the committee be referred to the executive board. They will have more time to think it over and will probably be able to settle it on a satisfactory basis. I offer that as a motion.

THE CHAIRMAN:—Is there a second to Mr. Estep's motion? The motion is not supported. Well, in the absence of any specific instructions, I presume the board will discontinue the committee.

Action Taken at Meeting Held Friday Morning, Oct. 1, 1915.

Mr. B. D. Fuller:—I attended the steel meeting yesterday morning, which was very interesting. I did not attend yesterday afternoon. I understand, however, that action was taken which I think ill-advised, namely, that the Committee on Standard Specifications for Steel Castings be discharged, and I would like to make a motion that this action be reconsidered and that this committee be continued for another year.

The Chairman:—The motion yesterday afternoon, Mr. Fuller, was not to the effect that the committee be discharged, but that the report be laid on the table, and the gentleman who made the motion to that effect, Mr. H. E. Field, announced that in his opinion more harm than good would result from the continuance of the committee and advised that we do nothing to stir up the American Society for Testing Materials. I advised the meeting that my correspondence with the A. S. T. M. was such as to make me know that they courted our co-operation and I suggestetd a negative vote. The meeting was poorly attended at that particular time and the motion introduced by Mr. Field to the effect that the report be laid on the table, was carried. I then asked what the sense of the meeting was towards continuing the committee, suggesting that it was not necessary to continue it at all if they were not going to make some disposition of the committee's report, which had been prepared after considerable thought, but no action was taken on that and if it is the sense of the meeting here today, that this committee should be continued and that work should go on, a motion to take up the report from the table and accept it as a preliminary report with instructions to the committee to continue its work, would be proper and regular.

Mr. B. D. Fuller:—I make such a motion, namely, that the report of the committee be taken from the table and accepted as a preliminary report and that the committee be continued.

The motion was seconded by Major Jos. T. Speer and adopted.

The Chairman:—I will appoint the members of that committee later.

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Causes of Shrinkage Cracks in Steel Castings

By William R. Bossinger, Marion, O.

Shrinkage cracks in steel castings constitute a common defect of steel foundry operations. The cause of shrinkage cracks is the same for all castings, but their locations are never identical, owing to the varying forms of different sections. It is not unusual to make castings from one pattern for a period of several months without being troubled by this defect, yet suddenly all of the castings from one heat will develop these cracks. If it were possible to prevent steel from expanding or contracting, this difficulty would be overcome, but since this is beyond control, the alternative must be accepted and this phenomenon must be contended with, namely, the contraction of the steel after the mold is filled. To reduce these defects or to eliminate them entirely, every effort should be made to prevent setting up solid walls that will cause the metal either to stretch or crack when the force of contraction is brought to bear on the walls of the molds.

Numerous appliances, devices, etc., are resorted to to overcome this defect, including the use of brackets, chills, tie bars, the use of sawdust or cinders in the cores, maintaining the metal at a minimum temperature when pouring and keeping it as low in sulphur as possible, as too high a percentage of the latter element is one of the common causes leading to shrinkage cracks. Long castings with attached ribs, flanges or lugs will crack if the sulphur is not well under 0.05 per cent in basic steel, regardless of the fact that other properties and conditions may be favorable to the elimination of this defect. While the various causes leading to shrinkage cracks are well-known to the management of steel foundries, nevertheless this will not eliminate losses from this cause until a knowledge of the cause of shrinkage cracks is imparted to all of the men con-

stituting the organization. The success in keeping down shrinkage cracks is based upon the training of the men who are directly responsible for the development of this defect. Each casting presents a different problem, as the thickness of metal and the lack of uniformity in section will change the location of these cracks in one casting as compared with another of an entirely different form. To train the shop force in eliminating difficulties from this cause, the common sense of the employes is a contributing factor of no little importance. Theory and practice combined, as well as previous experience, likewise should be taken into consideration. It is not unusual to stop cracking in one part of a casting, only to have this defect develop in another part of the same piece. This, however, should not prove discouraging, as it indicates that proper methods are being taken to prevent these defects. The law of the segregation of metals should be recognized as being closely allied to the causes underlying the formation of shrinkage cracks. Segregation will cause the formation of shrinkage cracks on the outside surface of many castings.

The Use of Chills

The free use of chills is recommended, as they will reduce this defect by controlling the cooling to a greater extent than the use of brackets. Unless efforts are made to prevent the employment of chills that are too large or heavy, or which extend over onto the junction of heavy and light sections, the chills will increase the tendency to crack. If the chill is too large, it will cause shrinkage cracks at the point of the chilled face. This is caused by the too rapid contraction of the casting directly underneath the face of the chill. When the chill is of the proper thickness, it causes the heavy part of the casting to pass through the first stage of contraction, imparting to the metal sufficient strength to meet the stresses caused by passing through the first cooling stage. Stresses in the chilled parts of steel castings are eliminated when the proper chills are employed. The chills will absorb heat from the casting until they reach a temperature of 1,400 degrees Fahr. and on cooling with the casting all stresses should be relieved as the casting strains are released by what practically

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constitutes annealing at this temperature. The use of chills is resorted to for the purpose of reducing the size of feeders on many castings. The chills are inserted in the molds over lugs and flanges that have light, thin sections on top. A chill should be of sufficient size to set the heavy section of metal before the metal in the lighter section has left its fluid state. In this way fluid steel will be carried to the chilled part and other fluid steel will be drawn from the feeder to replace metal taken from the lighter section. Another reason why the chill is to be favored in place of the use of brackets is that the chill will fall out of the mold when the casting is shaken-out, whereas the brackets have to be chipped off.

Improper Gating

Improper gating also is frequently the cause of shrinkage cracks, forming hot spots in line with the flow of metal. If a flat casting is gated in the center and the metal is forced in one direction, causing the sand to absorb and retain heat in this section of the mold, thereby causing a hot spot in the casting resulting in a shrinkage crack, it can be attributed to the remainder of the casting cooling and contracting in advance of the center of the hot section. To further illustrate this point, an I-beam section will be considered which is gated in the center of the web. If poured in this way, the casting will be liable to crack, as the flanges will resist contraction and the center will be weakened by the higher temperature of the metal due to the method of gating in the web and this part of the section would not have sufficient strength to withstand contraction and the crushing of the sand walls on the flanges.

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Scientifically Correct Lenses for Industrial Use

By F. W. KING, New York

The importance of a careful consideration of this question will be realized when it is understood that over 90 per cent of the colored glass used today to protect the eyes from glare and consequent ultra-violet light is not only incorrect, but decidedly injurious.

That colored lenses have been used for years by operators with decided complaint is no more justifiable than the fact that operators worked for years around unguarded gears and other dangerous machinery without protest. The workman is usually willing to *take a chance,* but industrial plants cannot afford to do so.

Proper lenses can only be determined by careful laboratory experiments requiring special instruments and sources of radiant energy. The eye alone is incapable of selecting a colored lens that will afford protection from the most harmful rays because the latter are largely invisible. Lenses may appear to be of similar color, yet their transmission of harmful invisible rays may be far different.

How One Plant Standardized(?) Lenses

To make the matter clear, we will give a characteristic example of the manner in which a large plant standardized blue lenses for *protecting*(?) the eyes in such processes as oxy-acetylene cutting and welding. It was found that glare in this process was too severe. When No. 1 outfit was purchased, No. 1 operator was authorized by the company to select *proper* colored glasses. He brought back smoked lenses of different shades, brown, green, red, amber, blue, etc. He tried them all and decided that he liked the blue glasses the best, thereby choosing the most harmful. He was quite proud

of his *discovery,* which at once stamped him as an *authority.* When No. 2 outfit was installed, No. 1 operator was called as *color expert* and insisted that blue was the only shade to use, as he had tried *everything.*

By the same process of reasoning that decided that blue was the best color in the above case, a man feeling ill should go to the drug store and taste the different drugs and medicines and select the one that tasted best to him and thereby hand down to future generations a universal *cure* for all human ills.

The mere fact that operators do not complain is no indication whatever that grave harm is not being done to the vision.

Dangerous Invisible Rays

The invisible rays, both ultra-violet and infra-red, are very dangerous and must be guarded against. In addition to protection by the selection of proper colored lenses the operator often becomes a more efficient producer. We cite such an instance in a large steel plant where eight men were engaged in heating rivets in separate gas furnaces.

At a certain temperature these rivets assumed the exact color of the white hot walls of the oven, so that it was practically impossible to distinguish them. With eyes half-closed, the operator fumbled them with the tongs, wasting time; by wearing glasses of proper color it was no longer necessary to squint and all eye-strain was removed. By actually timing the operator it was found that he gained one hour per day. With eight operators the saving is obvious. Besides this, the goggles protect the eyes from flying particles and give the wearer greater confidence.

The invisible rays of shorter wave-lengths than violet rays are called ultra-violet, and the invisible rays longer than the red rays are called infra-red rays. Sunburn is due to the destructive effect of ultra-violet rays in sunlight.

The outer membrane of the eye may be destroyed by the radiation from the quartz mercury arc, carbon arc, oxy-acetylene flame, iron arc, etc.

In many industrial processes these harmful rays are present in relatively far greater amounts than in sunlight, and as there

is no protective medium, such as a large mass of air and water vapor between the source of these rays and the workman's eyes, the rays of extremely short wave-length reach the eye tissue in great amounts and the eye is permanently damaged, if not eventually blinded.

The infra-red rays, according to Sir Wm. Crookes, of "Crookes' tube" fame, are also harmful, and he attributes glass blowers' cataract to them. Thus is seen that associated with light rays powerful enemies of eye sight are lurking.

Rays at High Temperatures

The ordinary gas-heating furnace has a temperature of about 2,400 to 2,800 degrees Fahr., and colored protection should be used. Electric arc welding reaches as high a point as 6,450 degrees Fahr., but beyond this first mentioned temperature the increase in the ultra-violet is enormous. For example, the oxy-acetylene flame is 1,200 candlepower per square inch, and the arc weld, which is but 2,100 degrees Fahr. higher, is 100,000 candlepower per square inch, and in this process the ultra-violet rays will probably totally and permanently destroy the sight within three minutes if the eye is not protected.

It must be remembered that after 2,000 degrees Fahr. is reached the ultra-violet rays—which are thrown off at a lower temperature—reach the danger point, and it is absolutely necessary to use a proper colored glass to eliminate them.

We have carefully compiled for the steel industry a table of temperatures of different departments of this work. For protection from ultra-violet and infra-red rays, we have produced three types of glass. These are used singly or in combination for reducing the intensity of light to a safe unit which we have established.

Visible rays produce the sensation of color depending upon the wave length. Many other rays accompany light rays, but they do not excite vision. These are extremely dangerous because their presence is only made known by their harmful effects.

The rainbow shows the decomposition of light into component rays—the spectrum of sunlight. There are present, however, other rays in each side of the rainbow which are

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invisible. Owing to the absorption of the atmosphere and water vapor the invisible rays in sunlight are greatly reduced and are not so harmful as if they reached the earth in full intensity.

Colored Spectral Plates

The colored spectral plates, on the accompanying insert, show clearly the effect of different colored lenses and their value in eliminating dangerous rays.

All white spaces within the black lines indicate absorbed light, whether visible or invisible. Where shaded portions are shown, part of the ultra-violet or infra-red remain unabsorbed which, of course, may be dangerous to the eye sight.

Where white spaces show over the colored part of the spectrum it indicates that so much light or illumination is reduced. For example, the smoked glass cuts illumination about two-thirds. With such a glass, a workman could not see to walk about besides the fact that grave injury would be done to the eyes by allowing injurious light to pass.

The answer to the whole proposition is to have a true photometric scale arranged exactly according to the temperature at which the operator works.

Electric Arc Welding

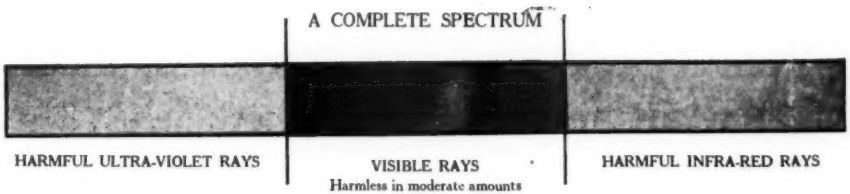
For electric arc welding so dense a color is used that it cuts out all ordinary vision, yet for welding it has the same relative effect upon the eye and its vision as a lens infinitely lighter in color.

We use in our business over 100 combinations of glass to obtain correct results and it is ridiculous to attempt to gain the same results by the use of half a dozen.

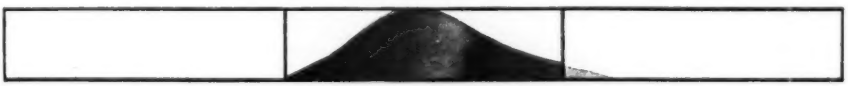
The use of blue glasses, except the Pugh glass used by open-hearth operators, should be at once abolished as should all forms of smoked or greenish smoked glass—amber, red, etc.

The combination of red, green or blue used for arc welding should be discontinued, as should all of the smoked glasses for oxy-acetylene welding and cutting. The latter are especially inefficient and their use very dangerous.

SCIENTIFICALLY CORRECT COLORED LENSES FOR INDUSTRIAL USE



Visible rays produce the sensation of color, depending upon the wave-length. Many other rays usually accompany light rays, but they do not excite vision. These are extremely dangerous because their presence is made known only by their harmful effects.



AKOPOS GLASS

These lenses do not transmit harmful invisible rays and are recommended for temperatures around 2000 degrees Fahr.

SANIWELD GLASS

These lenses, light and dark shades, do not transmit harmful invisible rays and are recommended for temperatures from 3500 to 4300 degrees Fahr.

ARKWELD GLASS

These lenses are a powerful absorbent of visible rays and are recommended in combination with the second and third colored lenses, illustrated on this page, for temperatures approximating 6400 degrees Fahr.

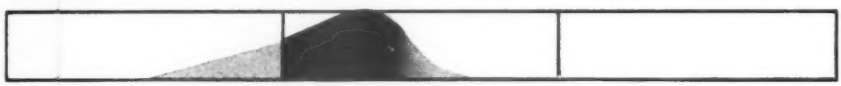
INCORRECT COLORS OF LENSES IN GENERAL USE

COBALT BLUE

Cobalt blue glass is exceedingly dangerous because it transmits the harmful invisible rays as freely as clear glass. Its use should be abolished except where temperatures must be judged, as in the open-hearth. It is incorrect here, but it is not practicable to teach melters a new color.

RED GLASS

Red glass is dangerous because it transmits infra-red rays and distorts colors too much.



GREEN GLASS

Green glass transmits ultra-violet and also distorts colors.

SMOKED GLASS

Smoked glass is deceiving, reducing the visible, but transmitting the dangerous invisible rays. Smoked glass lenses sometimes are furnished by manufacturers of oxy-acetylene outfits, but are about the worst that could be used for this process.

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Tests of Lenses for Foundry Goggles

By F. W. King, New York

Few foundrymen realize the tremendous advances made the last few years in the design and construction of goggles used to protect the eyes of chippers and other foundry operatives. A comparatively short time ago almost anything in the form of a 10-cent spectacle was considered quite proper, and only recently has the importance been realized of using lenses of ground optical glass, especially heat-treated to withstand a heavy blow. Contrary to the general belief, only a few types of goggles are provided with such lenses. Some foundries are still using masks or protectors made of wire mesh, but as a rule, they are being rapidly abolished, as the men complain that constantly looking through a screen tires their eyes and it is a fact that a screen cuts down the illumination 30 per cent and makes vision bad enough to be dangerous to safety welfare. The price of a goggle no longer is the first consideration. Competition is too keen for the goggle manufacturer to charge a fancy price for them. More than 100 types of goggles are on the market, the cheapest being sold at about 75 cents a dozen and the best, at $11 a dozen. Large quantities are sold on a scale down according to the number ordered. The cheaper type is worth possibly 75 cents, certainly no more. Like anything else, one receives just about what he pays for. The finest goggles are the best value to be had for the investment. Costing a little over 90 cents a pair wholesale, the same quality of goggle would retail at about $2.50.

No large concern, progressive in safety work, considers anything but the best. Frequently, the loss of an eye, through the use of improper goggles, costs enough to properly equip a county with goggles, to say nothing about the humanitarian features of the case. Generally speaking, the largest manufacturers are furthest advanced in safety eye protection and on account of the great hazard involved in the employment of

a large number of men they have demanded better and stronger goggles and lenses than at first, could be furnished.

The first requirements was that the entire frame, including temples, etc., had to be made of metal that would neither tarnish nor rust, so that it could be properly disinfected. This was not an especially difficult proposition and it was successfully worked out. Now the entire frame, including the screens, is made of a special German silver alloy, which meets all requirements.

The United States Steel Corporation was the first to adopt a standard of required strength for lenses, and other large manufacturers have drawn up similar specifications. The Illinois Steel Co., Chicago, has designed a drop test machine, Fig. 1, for testing lenses with a steel ball, magnetically relieved from a height of 21 inches.

How the Test is Made

The test is made as follows: Out of every gross of goggles received, one dozen are selected at random and the lenses of 25 per cent of these must stand, without breaking, fifteen 21-inch blows of a ball weighing 16.25 grams. When the glass is broken the pieces must hang together and not splinter or fly in towards the eye. If the goggles will not pass the test, the whole shipment is refused. While some lenses would pass this test, it was agreed by manufacturers and users that stronger lenses would be desirable and as the result of a large amount of research, lenses have been developed which will withstand a much greater impact than that provided by the Illinois Steel Co.'s specifications.

The Workman's Compensation Service Bureau and the Compensation Inspection Rating Board of New York recognize the importance of the use of goggles and respirators in industries where the eyes and lungs of workmen are exposed by allowing a 1 per cent credit on the insurance rate. The clause referring to this credit in the Universal Analytic Schedule, follows:

In all industries where necessary, and where workmen are furnished with approved types of goggles and where those engaged in dusty places are furnished with respirators, 1 per cent credit on insurance rate.

The importance of this cannot be overestimated. Realizing the cost of goggles, the recognition of the liability companies is certainly a fair one and offers financial inducement to

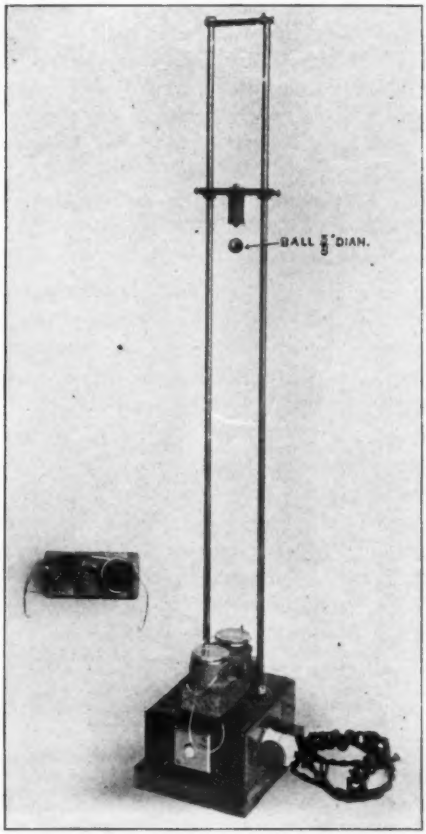

FIG. 1—LENS DROP TESTING MACHINE

the employers to furnish their employes with eye protectors of approved types.

Further details may be had by reference to the "Universal Safety Standards", Machine Shop and Foundry edition, page

287, issued by the New York Workingman's Compensation Service Bureau.

In addition to the standard already outlined, the Underwriters' Laboratories have adopted specifications which appear on page 480.

It will be noted from the foregoing that considerable thought and attention has been given to this important subject by institutions absolutely unprejudiced in the standardization of goggles, and it is suggested that the American Foundrymen's Association might do worse than adopt these same specifications. The specifications of the Underwriters' Laboratories only recently have been issued and they are much more rigid and exacting than those previously adopted.

It might be added that there has been considerable criticism of the drop test as not reproducing correctly the blow of a chip of steel traveling at a great velocity. A similar test of lenses is made by the use of a pendulum, and by lengthening it's swing, any desired impact may be reproduced. Lenses which satisfactorily pass the drop test also pass the pendulum test.

Lenses have been developed, which not only will pass the impact test of a 1-ounce ball, ⅝-inch in diameter, but will not break from the force of a blow of a 9-ounce ball, 1½ inches in diameter. The test is almost unfair, since the goggles are mounted rigidly on a hard rubber pad, whereas in actual use, when a blow is struck, there is a spring of the goggle in addition to the padding afforded by the skin and flesh of the wearer.

Specifications for Chippers' Goggles and Description of Testing Machine[1]

1.—The drop test machine consists essentially of a support for the goggles, made of white pine; the support is designed to accommodate the goggles under test in such a manner that the frame of the goggle is given proper bearing on the rubber and

Drop Test Machine

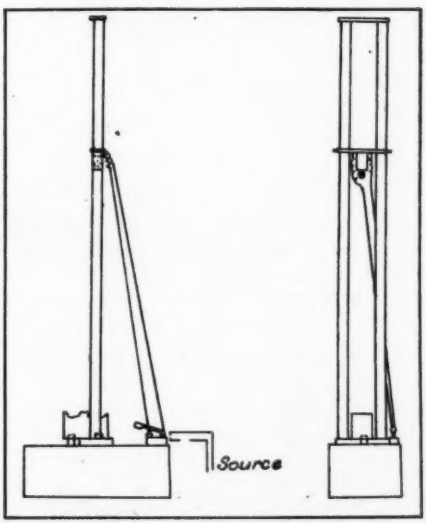

FIG. 2—GOGGLE TESTING APPARATUS

Diameter of ball, ⅝-inch; weight of ball, 16.25 grams or 0.0359 pound; height clear drop, from bottom of ball to upper surface of glass, 21 inches; energy per blow, 0.752 inch-pounds.

cotton composition strips, without permitting the lens itself to rest on the support or to receive any "backing", other than that naturally given by its own frame. A representative form of support is shown in Figs. 2 and 3.

[1]Adopted by The Illinois Steel Co., Chicago.

Height of Drop

2.—The height of drop shall be 21 inches from bottom of ball to the surface of the goggle lens.

Size and Weight of Ball

3.—The ball to be made of steel and hardened. The diameter will be 5/8-inch and the weight not less than 16 grams. When releasing the ball it must fall freely without any initial momentum.

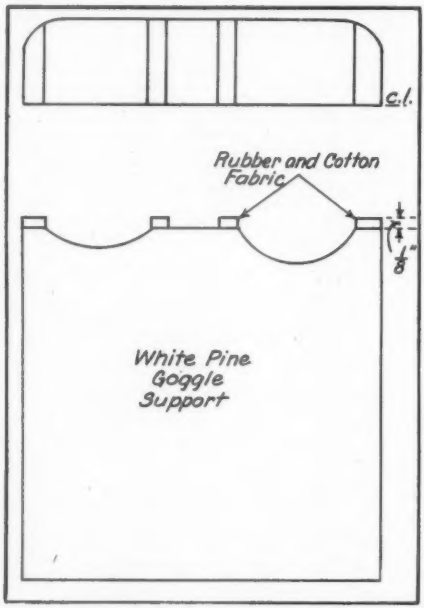

FIG. 3—TOP AND SIDE VIEWS OF GOGGLE TESTING SUPPORT

4.—Extreme variations allowed in the thickness of a single lens, O meter 0.0005. The measurement of the thickness to be taken with a standard gage used by opticians at five points, as shown in Fig. 4.

5.—Extreme variations in thickness allowed between two lenses of the same pair of goggles, O meter 0.001. The measurement of the thickness of each lens to be taken as described in paragraph No. 4.

Number of Blows

6.—The maximum number of blows to be given is fifteen; the blows to be given consecutively on the center of the lenses and on the surface of the lens which is exposed to flying matter.

Number of Tests

7.—On each shipment of one gross or more of goggles, one dozen of the goggles must be tested as described in paragraphs Nos. 4, 5 and 6, and of this dozen, 25 per cent, or three pairs of goggles, must stand fifteen blows without breaking or cracking. This means that the six lenses of the three pairs of goggles in the test dozen must be intact after fifteen blows. If less than 25 per cent stand the test the entire gross will be rejected.

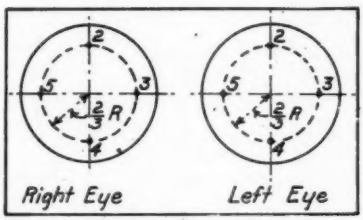

FIG. 4—POINTS AT WHICH LENS THICKNESS IS GAGED

Flying Chips of Glass

8.—If in the test dozen of goggles any goggles break under the drop in such a way that glass will fly from the inside surface of the lens—meaning the surface which is next to the eyes of the man wearing the goggles—then the entire gross will be rejected, even if three pairs of goggles have stood the number of blows required in paragraph No. 7.

Apportioning Costs of Tests

9.—The cost of the dozen of goggles used for the test will be divided equally between the goggle manufacturer and the purchaser, providing the goggles stand the test. If they do not stand the test, the cost of the rejected dozen will be borne entirely by the goggle manufacturers.

The testing is to be done under the supervision of the buyers' representative.

Laboratory Standard for Examination and Test of Type I Goggles with Plain, Uncolored Lenses[1]

General

Goggles are classified as follows, according to the service for which they are intended:

Type I.—To be used for heavy grinding, chipping and general shop work.

(Type II.—To be used around hot metals and Type III are used outside of the manufacturing field. These types will not be considered in these specifications.)

EXAMINATION

The following features should be carefully noted and recorded:

Lenses

1.—*Quality of Glass.*—All lenses should be of clear optical glass free from flaws (waves, air-bubbles, etc.) and ground on both sides.

The lenses must not show a variation in thickness of more than 0.0040 inch. Fifty per cent of the submitted samples should be examined as outlined above.

2.—*Size.*—The minimum allowable diameter of the lens on any axis is 1½ inches.

3.—*Lens Replacement.*—The lenses should be so designed that replacement without injury to the frames is possible and should be distinctively marked so that no similar stock size of any inferior quality of lens may be substituted.

Frames

Frames are to completely surround the lens and otherwise be so shaped that they will closely fit the face of the wearer. They shall be made of a material which is light and strong, and easily adjusted to fit the individual without danger of breakage. Joints to be secured by rivets, pins, solder or screws.

[1]An outline of specifications for goggles to be used for heavy grinding, chipping and general shop work, adopted by the Underwriters Laboratories, Inc., Chicago, under the direction of the National Board of Fire Underwriters.

Where frames are adjacent to the nose they shall be cupped, or otherwise designed, so as to form a complete guard and leave no openings at these points for the entrance of foreign materials.

Replacement of Lenses.—The goggle frame shall be so constructed that in the event of a lens being broken it may be readily replaced without unduly distorting or damaging the frame, and frames must be uniform to insure perfect interchangeability.

Guards or Shields.—Shields should be made of light, strong, durable material which may easily be kept in a sanitary condition. They should allow a clear vision in every direction, should have rounded edges, and shaped to fit the face closely without causing discomfort, but must not be sufficiently rigid or so shaped that they may cause injury if a severe blow should drive them into the temples. If wire screen is used it should be at least 40-mesh, but not fine enough so that it is easily distorted or jammed. If perforated metal is used the holes are to be not larger than 0.02-inch in diameter and shall not interfere seriously with the clear vision of the operator. It is important that proper ventilation be provided in a manner which does not defeat the function of the goggles.

Weight The complete goggle shall not weigh in excess of 71 grams or 2½ ounces.

Marking Each lens shall bear a distinctive marking and the frame shall be marked with the name and address or trade mark of the manufacturer.

Comfort Test

In order to obtain a representative test of the practicability and adaptability of the goggles they should be tested as follows:

Six observers are each given a pair of goggles which are to be worn for a period of one hour. Each observer is to be given the size of goggle which best fits his face and the minor adjustments are to be made to secure as nearly a perfect fit as possible. At the end of the hour the observers will make a report as to their experience bearing upon the comfort of the goggles, especially at the following points: Back of ears, bridge of nose and temples.

Hot Water Test

Goggles must be subjected to boiling water or steam in order to sterilize. The following test indicates whether the samples may be expected to withstand extreme temperature changes without cracking:

Goggles are to be immersed in cold water, temperature 10 degrees Cent., for 15 seconds and plunged immediately into boiling water, temperature approximately 100 degrees Cent. A failure of 10 per cent of the lenses so tested will result in the rejection of the entire lot of goggles.

Corrosion Test

Frames

Perspiration will corrode the metal portions of goggles to an objectionable degree unless they are made of materials, or provided with protective coatings, which resist corrosion. The following test is for the purpose of determining the ability of the goggle to resist corrosion:

The goggle shall be immersed in a solution containing 10 per cent, by weight, of sodium chloride, for a period of 24 hours. Temperature of solution to be not less than 20 degrees Cent. nor more than 40 degrees Cent. at any time. Goggle should be removed from solution without wiping and allowed to dry for one hour. It is then to be examined for corrosion and, if found to be seriously affected, the manufacturer must show that proper protection has been provided before the goggle may be recommended for labeling.

Strength Test of Lenses

(This test is approximately the same as that required by the Illinois Steel Co., Chicago, as noted on page 477, with the exception that 25 blows are struck and 90 per cent of the shipment must stand this test or the entire shipment is refused.)

The frames must withstand the tests outlined herewith, without taking a permanent set:

1.—*Load perpendicular to plane of lens. Eight-ounce test.* —The right lens is laid flat on a table top with nose bridge and left lens projecting beyond the edge of the table. A spring balance is connected to the outermost portion of the frame around the left lens and a force of 8 ounces (½ pound) is

exerted in an upward direction. If the frame shows permanent set or distortion the goggle is rejected. If 25 per cent of the test lot fails to pass this test the lot is rejected.

2.—*Load applied in the plane of lens. Four-pound test.*— The right lens is held vertically in the hand and the lower edge of the left lens frame is pressed against the center of the pan of a balance which carries a weight of 4 pounds on the opposite pan. The pressure on the goggle frame must be exerted so that the weight is raised until the scale indicator reaches the balance position and may then be released. If the frame shows a permanent set or distortion the goggle is rejected. If 25 per cent of the test lot fails to pass this test the entire lot is rejected.

Hot Metal Test

Inasmuch as Type I goggles may be worn by men handling molten metal such as babbitt, etc., it is essential that they serve as safeguard against injury to the eye from this source and, therefore, must pass a test consisting of the dropping of 5 grams of molten lead, three times on each lens, from a height of 18 inches. No piece of glass shall leave the frames under these tests, or the entire lot shall be rejected.

The Electric Arc in the Foundry

By Robert E. Kinkead, Cleveland

The application of heat and mechanical pressure to iron is the basis upon which the iron and steel industry is founded.

Each forward step in the development of methods of applying heat and pressure to iron has been the introduction to a forward step in the industrial affairs of mankind. Mechanical pressure was probably first applied to iron by a hard stone in the hands of a savage, then came the hand hammer, the power hammer and finally the rolls. The first application of heat was probably made by the same savage using a charcoal fire and the blast of his lungs. From this modest beginning came the bellows forge, the blast furnace, the open-hearth, the bessemer converter and the electric furnace.

Reduction of cost, whether it be measured in the arrowheads and battle-axes of the ancient savage, or the shrapnel and machine guns of our "modern civilization," has been the economic necessity back of every new development.

Employment of the Electric Arc

The use of the electric arc in foundries, both as a prime and an auxiliary source of heat, is economical at present. The electric arc furnace uses the heat liberated by the arc as the prime and only source of heat. The electric arc welding process which, so far as foundry work is concerned, may be considered as simply an auxiliary heat producing process, likewise employs the heat of the electric arc to melt the metal. The economy arising from the use of the electric arc for the melting of metal is the result of the low price of electric power and the high degree of effectiveness of the arc for this purpose. Since this paper is to deal primarily with the use of the electric arc as an

auxiliary source of heat in the foundry, my remarks will be confined from this point to the principles and application of what is generally known as the *electric arc welding* process.

The use of the arc as an auxiliary means of applying heat to the metal in foundries lies in four rather well defined channels:

First.—Reclaiming of steel and malleable castings which would otherwise be scrapped due to defects originating in the casting process, such as sand spots, low spots and shrinkage cracks.

Second.—The perfection of steel and malleable castings which would not be scrapped.

Third.—The manufacture of steel castings which owing to the shape will always crack upon cooling. (The cracked casting is welded together.)

Fourth.—The cutting of gates and shrink-heads.

Two Ways of Employing the Arc

There are two ways in which the arc is used to accomplish the above operations, which may be distinguished by the kind of electrode used. The arc may be drawn between the casting and a carbon electrode or between the casting and a metal electrode. The first method is called the carbon electrode process and the latter is called the metal electrode process. Where metal is to be added in the carbon electrode process, it is fed into the arc in the form of a *melt bar*. In the metal electrode process the electrode itself melts and runs into the molten metal of the casting.

The manner in which the electric arc is produced is simple. The positive side of a low voltage, direct current circuit is connected to the casting and the negative side of the circuit is connected to the electrode which is held in a suitable holder. The electrode is brought in contact with the casting and is quickly withdrawn. The current of electricity flows through the casting to the point nearest the electrode and through the air to the end to the electrode. The heating to incandescence of the air through which the current passes forms the visible arc. The greater part of the electrical energy is transformed into heat in the

metal where the current of electricity is passing into the air. The quantity of heat liberated by the arc is proportional to the current density in the circuit and the length of the arc.

The effect of the heat of the arc upon the metal is the same as the effect of heat produced by any other method. While the temperatures reached by the arc are higher than those reached in any other process used in the foundry, the danger of overheating the metal is no greater than in any other part of the heating process when the operator of the arc becomes accustomed to handling the arc. Owing to the fact that the current of electricity flows from the casting to the electrode, a carbonization of the metal, when the carbon electrode is used, is prevented unless the operator deliberately dips the electrode into the molten metal. In the metal electrode process, of course, no alien carbon is present and no carbonization can take place unless the electrode itself is high in carbon. The tendency of the arc is always to burn the impurities out of the metal. The degree of refinement depends upon the length of time the metal is subjected to the heat of the arc.

Cost of Using Electric Arc

The cost of using the electric arc as an auxiliary heat producer in the foundry along the four lines referred to is lower than the cost of using any other method to accomplish the same results. The oxy-acetylene flame offers the only other method by which the same results can be obtained. The cost of producing a given number of heat units by the electric arc process is about one-third the cost of producing the same number of heat units by the oxy-acetylene flame at the current rates for gas and electric power. In foundry work one unit of heat produced by the electric arc will do more than three times as much work as one unit of heat produced by the oxy-acetylene flame, because the arc produces the heat in the metal rather than external to it. On work where metal is to be added to the casting, one operator with the arc will do from two to three times as much work as one operator with an oxy-acetylene torch in the same length of time. In foundry welding work, therefore, the arc may be relied upon to do the work at one-half the labor cost and one-third the heat cost of operating the oxy-acetylene torch.

The apparatus for the furnishing of an electrical circuit, suitable for welding, naturally affects the cost of power for welding. The figures given are for apparatus which does not use resistance ballast in series with the arc circuit.

The ordinary type of machine known as an *arc welder* is nothing more than a motor-generator set which takes power from the supply lines at whatever voltage the power is purchased, either alternating or direct, and delivers direct current power at about 75 volts. Resistance ballast is used to bring the voltage down to 50 or 25 according to whether carbon or metal electrode is used.

The type of machine which does not use resistance ballast in the arc circuit uses from 50 to 60 per cent less power to do a given amount of welding than the ordinary *arc welder* because there is no unnecessary power waste.

The economies which may be effected by the use of the arc in steel and malleable iron foundries along the lines indicated are great. In fact, the time is at hand when the use of the arc may be considered a part of the process of manufacturing these castings. In view of the extensive use of the arc process in the reclamation of worn-out steel castings by the railroads and other large users, the use of the process in steel foundries is properly considered an economic necessity.

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Report of A. F. A. Committee on Safety and Sanitation

Your Committee on Safety and Sanitation has not had opportunity to meet together since it was appointed, but has discussed by correspondence some of the functions which might be performed by the association in safety and sanitation propaganda. Numerous ways have suggested themselves as likely methods for continuing to the best advantage the association's work for safety in foundry operations.

The publication of occasional bulletins prepared by the committee and approved by your officers would probably be of considerable value in stimulating the personal interest of the members along specific channels that bring home the Safety First idea with emphasis. Indeed, your president gave his tentative approval to the preparation of matter for two bulletins during the year, but unfortunately compilation of such matter has been delayed.

It is proper at this juncture to refer to a great loss sustained by the safety movement in the death of Past President Thos. D. West, who was undeniably the foremost member of the association in this field. The summons which came to Mr. West robbed your committee of its most zealous and honored member. Arthur T. Morey, another of the five original appointees found it necessary to withdraw early for lack of time to give to this committee work. M. W. Alexander, originally appointed as a member of this committee, through an unintentional and unhappy oversight on the part of the chairman of this committee did not understand until recently that he had been appointed, and requested that he be excused from duty. The remaining members recommend as a fitting memorial to Mr. West, the publication of a special safety bulletin, issued by the association, given circulation in every foundry in the United States and Canada irrespective of

membership in this association, and dedicated to the memory of our honored Past President, whose later years were characterized by the utmost zeal for safety in foundry operations. It is suggested that this bulletin be an abridged compendium of the most instructive matter relating to safety in foundry operations which has already been published, and that this be supplemented by such original matter as may seem best to the compilers to include.

Work of National Safety Council

The committee feels its position to be entirely consistent in speaking in positive and commendatory terms of the great work being done by the National Safety Council, and in recommending that all foundry concerns hold membership in that body. Only a large, systematically governed organization with substantial resources could undertake the educational work which the Council carries on through its weekly publications that touch all branches of industrial activity. It is well that the safety committees of other societies devoted each to its own special field, but, incidentally giving proper heed to the conservation of life, should encourage and receive help from an organization whose sole function is the maintenance of the human body in the strength and beauty given it by its Creator.

President Bull has advised the committee of the invitation extended the association to take part in the work of the Joint Conference Board on Safety and Santitation, now made up of representatives of the National Founders' Association, the National Association of Manufacturers, the National Metal Trades Association and the National Electric Light Association. Your president has secured definite information concerning the expense of such co-operation, has stated that he will present this matter to this association during this meeting, and has suggested that the committee present its views on the matter. The committee, one of whose originally appointed members is prominently identified with the Conference Board referred to, feels because of that fact that it should be excused from debating such a question in this report, and believes it is proper to rest the matter in the hands of the association or its executive board. Meanwhile, the committee desires to

express its appreciation of the hearty assistance proffered by Mr. Alexander, secretary of the conference board on safety, whose bulletins issued for the National Founders' Association have received wide approval.

Mechanical safeguards are now in pretty general use in modern foundries. It is only the out-of-date shop which is conspicuous for neglect in providing them. What is now most needed is education to make men *think* safety. This is strikingly attested by the fact that in a foundry employing 850 men, during the first six months of this calendar year, there were, all told, 57 accidents involving loss of time. Not one of these was due to the lack of mechanical safeguards. All were the result of carelessness either on the part of the injured, or negligence of their fellow-workmen. It was an accident that could have been avoided by proper care that caused the death of Mr. West, and his untimely death gives most compelling emphasis to his constant injunction to "be careful". It is, as we believe, the duty of your committee in this respect to lay greatest stress on personal caution rather than on safety equipment, to which due attention should be given in the matter for the proposed memorial bulletin.

Recklessness, National Characteristic of Americans

Justly, or not, the average American is credited with recklessness as a national characteristic. Perhaps this trait is common to the entire human race. In any event, we must admit as a result of our observations that workmen speaking foreign tongues either are naturally careless, or become through association as much so as their American brothers in industry. It cannot be doubted that the foreigner is quick to cultivate many American habits even if he be slow to acquire the language of his adopted country. It follows that as the American is admittedly reckless, the foreigner does not as a usual thing materially better his chances for immunity from accident by the process of becoming Americanized.

The reverse condition then would seem logical, namely, that as the American workman acquires the safety habit, the observing and imitating foreigner becomes more careful, as indeed he must be if he would escape the results of foolhardi-

ness; for given the same chances of accident he runs the graver risk since he neither understands nor moves as quickly as does his English-speaking colleague. The best way to educate the foreign workman would seem to be by the example of his adopted countryman. The importance of the unconscious influence of the American on the European in cultivating habits of safety and sanitation is emphasized because of the high percentage of injuries and cases of infection among foreign-born employes of foundries.

Watchfulness Against Danger

The individual's own safety, therefore, while always the primary consideration, is attended with a heavy, if less convincing, responsibility in the force of example. How can we best impress upon our fellow-Americans the need of watchfulness against danger? Suggestive phrases, pictures showing the terrible effects of carelessness, and brief, but striking statistics all posted on bulletin boards erected in numerous and appropriate places in the shop play very important functions. Occasional talks by those who know how to hold the attention of working men by language which is blunt and compelling are very helpful. Systematic study of safer working conditions by committees of men tactfully inspired by the management brings to the surface many an obscure element of danger, and greatly stimulates the safety thought while occasionally demonstrating the need for a guard to which attention had not been given. Suitable appreciation of carefulness in men and departments always helps greatly.

Yet, when all is said and done, there remain not a few individuals who take foolish chances, causing danger to themselves or others, or both. We may blame the frailties of human nature for this and other deficiencies and deplore our ability to work it over, but we are stopping at the very kernel of the matter if we thus fold our hands. Since careful or careless men develop from children of similar tendencies, we must do our part to educate the rising generation to the necessity for eternal caution. The thoughtless child can have his attention quickly centered on a word picture that has a human interest. The public schools afford the ideal opportunity for inculcating

a national safety habit, and a proper regard for sanitary living. Happily, there are now available numerous moving picture films vividly depicting the dangers of city streets, hopping cars, inattention to primarily trivial wounds, etc., that impress upon the minds of boys and girls as perhaps nothing else could do the necessity for thinking always of doing things the safe way. The larger school systems are making a splendid use of these picture reels which are easy to secure for temporary use, and which should soon be employed in every community large enough to boast of schools conducted along progressive lines. The members of this association can do much to induce local school boards to give this matter careful attention. Each individual who has a financial or supervisory interest in a foundry owes it to himself, to his successors and to the chance-taker to inculcate by every conceivable and sensible means the safety habit in the men who come in contact with him in the day's work, and in the children who are growing up to take our places. If we succeed in making our boys and girls reasonably careful, the problem of securing for the future, foundrymen who think to avoid danger will solve itself.

A. W. GREGG, CHAIRMAN.
F. H. ELAM.
Committee on Safety and Sanitation.

Foundrymen in the Making

BANQUET ADDRESS BY ARTHUR A. HAMERSCHLAG[1]

The previous speaker (John Kendrick Bangs) gives me so much food for thought—so much of the philosophy of life—that words come to me but poorly since my emotions have been thrilled and touched by the anecdotes with which Mr. Bangs has entertained us this evening. Nevertheless, responding to the subject which has been assigned me; "Foundrymen in the Making", I am going to take the liberty of discussing with you certain educational problems which confront us who have the duty of influencing the children of today to become the men of tomorrow. It would be folly for me, in this company, to limit my remarks to technical details and I can only humbly sit at the feet of men like Mr. Seaman, Mr. Devlin, and Major Speer, who are the true deans of your industry. Nevertheless in the making of men who are to be most influential and important in the development of your chosen industry, the educator is privileged to enunciate his principles of procedure with the expectation that the industry will come to the support and aid of any movement which makes for growth and development.

Pedagogical Experiment at Pittsburgh

As a representative of the Carnegie Institute of Technology my remarks would be much more to the point if I could, in brief, transfer you to Pittsburgh, there to see in reality our conception of an educational establishment. Since that seems impossible this evening, now that the hour of humor, wit and pathos is past, will you bear with me while I seriously tell you of the pedagogical experiment which we have undertaken in Pittsburgh. It has been an experiment which has

[1]Director, Carnegie Institute of Technology, Pittsburgh.

lasted nearly ten years and we are convinced that we are moving in the right direction.

It is at conventions like this that educational propaganda concerning your industry must be discussed. Therefore, I am convinced that, even though the hour is late, you will be interested in hearing what we have done in the training of young men for the great fuel and metallurgical industries at the Carnegie Institute of Technology.

Manufacturers Influenced Instruction

In order to establish this institution upon a firm foundation and to be sure that we were quite familiar with the problem instead of doing it on a purely theoretical basis, or imitating the existing institutions, we decided to let the great manufacturing interests influence the type and kind of instruction which they thought was desirable for their industry; and I regret to say that but few of the manufacturers then had a vision beyond the production of semi-skilled labor. In my inquiries among them, I found them most concerned in the training of molders and workmen of a similar grade; but every now and then, I would meet two or three far-sighted manufacturers, who felt that the most important need in their industries was not necessarily the production of skilled workmen, but the kind of men whose mentality and skill combine to make the useful foremen or suprintendent. We all know that there is nothing so difficult as to go out into the market and buy brains and personality, and I think that you manufacturers will agree with me that if you had your choice of a dozen men of skilled capacity, and one capable, useful, well-trained brain with a personal equation, ready to go in and do the work that more or less falls to your lot, you would choose the single individual; and so we decided that we would be guided not by the voice of the majority, but by the opinion of the few who knew just what they wanted in the way of an exceptional man.

Now, in attacking that problem, we met certain problems. First of all we found that it was going to be extremely costly, and it was only in an institution in which the endowment was large enough to produce a big income, that it was possible to

do this. We decided, first of all, to select our student material at entrance, just as you select your raw products, and we found that we could not select them by any written test or any high school standard, or any standard heretofore put into effect, but that we would trust to the test which all of you use in the selection of your employes, that of personally interviewing the hundreds of students who applied for admission. I would like to state that at the opening of the institution we had over 5,000 applications for instruction. Out of those we personally interviewed 750 and then selected 120. With this group of carefully selected students we decided to give them all a uniform course of instruction consisting of basis studies planned to give them an understanding of fundamental principles supplemented by an opportunity to sense what life meant in industry. Our purpose was to open their eyes. They acquired a simple knowledge of the laws of physics, of chemistry, of mathematics, of English of our modern language, but a third of the time, exclusive of the time which they put into those studies they spent in the shops. Between terms we gave them an opportunity of visiting the great industries, of listening to men who could speak authoritatively upon all the important developments which had been made in industry in the Pittsburgh district; then we told these youngsters, after they had had their eyes opened and we had practically taken them up into balloons so they could look out over the whole wide expanse of industry, "Now tell us in which of these places you would like to land;" and after we had their answers to that question, we decided that we would find out whether they had any natural capacity for the thing they sought, and in nine cases out of ten, the students had chosen wisely; they showed a natural ability for the thing which they wanted to undertake.

How Natural Ability was Tested

How could we test that natural ability? A student who chose electrical engineering, for instance, necessarily would have to be thoroughly equipped in mathematics and physics, and only those who had exceptionally high grades in those subjects were eligible. A student who chose foundry practice would necessarily be one who likewise was interested in physics

and also in chemistry, but not necessarily with so keen a mind for mathematics; and then, having sifted these students into groups, we chose our teaching staff carefully, so that added to the professorial staff, we had gathered for the academic subjects men who had had a very long and extended practical experience in the industry in which they were going to teach. This decision involved difficulties because in the selection of these men we frequently chose those who knew how to do things, but did not know how to impart the reason why they did these things. But by elimination and from this small beginning we succeeded in the task and gathered an exceptionally strong staff.

Choosing Careers

Now, the one retarding influence in the development of our institution, curiously enough, has been the preconceived idea of the parents that their sons shall follow certain careers rather than the one in which nature has given them the greatest gifts, so I am going to make a plea tonight to the men of this organization to give their children the freedom of choice. When our forefathers came to this land, they came because they had the spirit or the blood of pioneers; they had their opportunity to go to a new land to make new conquests, subjugate the soil, extract the great resources of the land, and thus to build mill and factory. Young America finds all this done, and his father says, "Now we want you to grow up in my footsteps; do my work; do it as I have done it," and Young America, seeking his opportunity, wanting his quest for adventure, like a knight errant, going out to make his conquests, the finest prerogative of youth and the new generation, does not always want to follow the beaten track. He asks parents, school and college to give him a chance to be an individual. Youth seeks from education the weapon with which to go out and win a career, but it wants to have the right of choice. You men who have sons will do wisely if you will listen to your children, just as the Carnegie Institute of Technology listens to the voice of its students, because the chances are that if they hunger for an adventure in a new field, it is because within them they have other blood strains than those of their fathers, they have the

blood strains of the mother, and biologists tell us that the father and the mother contribute each a quarter, that other ancestry gives the other half, and it may be that in that other half there has come a strain of heredity, of interest, of aptitude, which is going to make it exertmely desirable for the youngster to be given his chance to do the best he knows and the best he can in the field in which he feels a natural interest; and so, in the making of the master foundryman, even as in other fields, we have found that if the students are studied they show us what they ought to be taught.

We give them the ordinary contents of our books; we teach them the fundamental sciences; we stimulate their imagination in their relationship to other arts; we give them the touch of the humanities; tell them something of the great labor Utopias; give them a clue as to the great commercial life of the world; and then we stop and we wait for the student to come and tell us what he wants, and if the student wants a little more metallurgy, a little greater knowledge of geology, if he makes inquiry as to why it is that we use one kind of fuel, we begin to get the clue as to what to give him to satisfy the thing within him and with which he is going to create for himself his own useful career.

Imaginative Thought

You foundrymen with your great experience must have been impressed today, as you went through that exhibition hall on the Pier, to see the great variety of machinery which is doing the work which men used to do. Each one of these machines represents an individual thought carried out in its expression by an engineer, foundryman, or an inventor. This imaginative thought serves the individual who invented the machine as the artist's inspiration serves the artist, so that he may depict his landscape or his portrait; just as it serves the sculptor, the mass of clay to be molded by him into a new shape, a new form, which expresses what is best in himself. Now, if this great work of the development of the foundryman is to be undertaken at all, it must have some support from those at the top. The great typographical industry for many years has had absolutely no school of printing or the graphical

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arts to which it could turn to get a supply of intelligence, or brains, and so this industry finally turned to us and said, "If you will start a school of the graphical arts, we will support it," and their method of supporting it is most unique; instead of merely publishing pamphlets and endorsing it in conventions and looking at it with interest, this Typothetae of America has virtually selected the students by sifting carefully its own employes in its own printing establishments and picking the most gifted youth that it can find and then subsidizing that youth to come to us for a complete system of instruction.

I want manufacturers to see the wisdom of taking the best youngsters in their shops and sending them to an educational establishment to get the kind of training which may equip them to be the men you are eager to get, and that is, training which will show itself in a higher output, greater efficiency, and greater results.

Few Real Foundry Schools

In America we have but few real schools of foundry practice; I regret that I must say it. I suppose we have as progressive a one as any other educational institution, but it still lacks in detail what we need in order to produce the real foundryman. Now these are some of the things we need to produce the real foundryman: First of all, we need a good foundry that should be well equipped; able to produce malleable castings as well as cast iron, steel castings, and castings made in brass, bronze, and in refractory metals; second, it needs an excellent equipment of molding machines to show the relationship between labor-saving devices and handwork; third, it needs chemical laboratories for a proper understanding of the chemical constituents of not only the castings which are made, but what goes in the cupola; to study what is best in fuel. Just think of the different varieties of fuel which today are available in America—coke and coal, oil and gas, electricity. Which man in this room can stand up and truthfully say that he knows which is the best fuel; which is the most economical; which is the only fuel which can make the purest and best castings? Then is needed a physical laboratory, a laboratory for the testing of materials, one in which you can fracture

your castings and determine instantly by photographic means what the structure may be; then there should be, in addition to that, a cost and accounting system, to teach students something about the relationship between input and output; courses in industrial economics so as to deal with the great labor questions and so that the transition period between doing things by hand and by machinery is going to confront the man who, by reason of his experience, has the right to live and exist; there is needed instruction in the academic branches and in these subjects you must have a definite bent so that the student may understand that, with his ability to express himself, he widens his usefulness to the foundryman.

Reading Drawings

Students must be able to read their drawings, their plans, and to prepare and read specifications, and out of them to bring, from the written or the drawn page, the pattern, the casting, and the finished product after it has gone through the machine shop. In addition to all of these, an opportunity for students to know something about the latest processes—and they cannot know about these latest processes in the limited environment of a school—they need to have your laboratories open, they need your shops, they need the chance to visit, and they need all that you can give them through the best men that you have in your employ, to come and say to them, "These are the things we have found won't work and these are the things that do work," and if you have all these things working together with some reward, commensurate to the amout of time and effort which these youngsters have got to put in in order to reach man's estate and get a foothold in your industry; why, you have got the beginnings of a foundry course of instruction which will attract Young America into that industry.

You know and I know that Young America turned from this industry because he saw it was an occupation in which dirt and grime were over-emphasized. And it was dirty work; the work in the sand was dirty, the odors were bad, the smoke that was belching out from the boilers and furnaces covered everything with soot, and the men who were working in it,

bare to the waist, surely were not the most pleasant sight to Young America, and if you want Young America to go into that field because he thinks it attractive, you, as employers, must make it attractive at the other end, you must let him see through that grime and smoke which we all know is being lessened by stokers and superior methods of firing and better and more economical use of fuel—you have got to let him realize that back of it all is a great industry that needs the services of the best men and that the rewards are commensurate with the best men making the attempt to go into that industry. We out in Pittsburgh are prepared to help this Association, but we cannot help it to the fullest extent unless you will co-operate. The Pittsburgh Foundrymen's Association has been the best friend we have had in that district, helping us to solve this problem.

Importance of Personality

Then, after your Association has lent its efforts in helping the schools, what else does the aspiring foundryman need? He needs one thing that counts a whole lot, and I expressed it briefly to a gentleman who was seated at my right when I said that, in addition to brains and skill, the man needs personality. Now, that is the most intangible phrase, perhaps, that you can give a group of people to think about, and still, if you look over your acquaintances, you will find some man whose personal equation is so big and strong that it leaves an indelible impress upon everybody he meets. It is the kind of man, the type of celebrity, which the distinguished speaker who preceded me talked about tonight. How are you going to give a boy a chance at acquiring personality? You cannot do it in an educational institution alone; you cannot do it in the home alone; you cannot do it in industry alone; the only way you can give it to him is to give him a chance to handle men, a chance to test himself. If we can create a few great personalities they are infinitely more precious to us than the thousands whom we talk about when we talk about educational systems. If you asked me which I'd rather have as a gift to Pittsburgh, the genius for organization of an Andrew Carnegie or the coal mines which lie in the hills, I would tell you that I believe

that the genius of a Carnegie has been more fruitful in its development than the mines; if you asked me which I thought was most important to Pittsburgh, the reservoirs of the oil which made so many men rich in Pittsburgh, or the genius of a George Westinghouse, I think I would choose the leader of men, George Westinghouse; and so when it comes to names like these, I think of the first citizen of Pennsylvania who was to have been our speaker tonight, born of humble people in Brownsville, educated as a patternmaker, millwright, a student of astronomy, he became the greatest living instrument maker, a man who has done more for precision in America than any man since the time of Clark—Dr. John A. Brashear. If you ask me, I would say, combine that with the living heart and genial personality of Brashear, and he is a bigger asset than anything we have in the State of Pennsylvania, and he was created and made, possibly, by the opportunities which I have described—of struggling with other men, of overcoming obstacles. Recently he has been grinding the great 60-inch reflecting mirror lens for Canada, and it is to be so accurate that it must not vary one two hundred and fifty thousandth of an inch in its surface; if it does, the beam of light falling on it, instead of coming back in a straight line, will be deflected by an angle too small for you and me to conceive, but large enough to throw away the calculations and mathematical accuracy of the great astronomers. Now, the man that can do that, the man who can make that kind of contribution, is one of the type of men whom we need most. If you had your choice tomorrow as to which you would have for your great foundry industry, new sources of steel in the form of iron deposits, new sources of fuel, or new sources of brains and personality—we would find some way to get the raw material—but we would find it very difficult to get along without the personalities which are necessary, and the brains with them, to make the American Foundrymen's Association realize its fullest possibilities.

War Orders

And now, in conclusion, I want to say a word about a thing which is rarely touched upon in gatherings like this, and that is how much we owe, because of our position as a neutral,

separated by an ocean, to Europe. I suppose there is no industry that is more interested today than this industry in war orders. I am sorry that we cannot help all the races of the earth without taking war orders, but nevertheless we can be helpful sometimes. After the great conflict is over and millions of men are left dead upon the fields of battle in Europe, the cost of war depriving many of these countries of their great resources, thrusting this terrible economic burden upon the mothers and children of future generations, I think America ought to do its part in helping to lift the burden of fatherless Europe. Whether we will it or not, at least half of our industrial growth this year is induced by the privations and the troubles of those who are over the seas, and I hope that this Association, when the war is over, will do its part to let Europe know that it was not consciously our program, as a neutral nation, to make it more difficult for them. Somehow, somewhere, the great business men of America are going to have the biggest ethical problem thrust on their shoulders that ever confronted any race of people. I want to see the American people rise to it and I hope you will do your part.

Report of A. F. A. Committee on Industrial Education

Your Committee on Industrial Education was appointed without definite instructions as to the work which it was to undertake. It was charged, in a general way, with the responsibility of determining how the committee itself, and the American Foundrymen's Association, which it served, could best advance the cause of industrial education, that is, the education which is appropriate for and useful to the future industrial workers of the country. After considerable correspondence, the committee decided that it would attempt to induce the members of the Association as individuals, and the Association itself as an organization to take a more active part in promoting industrial education in general and, particularly, industrial education in the public schools.

As many of the committee are engaged in educational work, it is quite natural that we should state the matter as if the important thing were to get the Association to do everything in its power *for industrial education*, while from your point of view, I suppose, the desirable thing is to get industrial education to do all it can to *advance the interests of the foundry business* and of industry generally.

Your committee has not once lost sight of the latter point of view, but we are convinced that it is through the agency of the public school classes that members of the Association will find the surest means of helping themselves, so far as they can be helped at all by industrial education.

Public School Adjustment

We do not take issue with those who would establish their own schools within the industrial plant, in fact we commend such a plan wherever it is feasible. We also commend the privately endowed school, such as the David Ranken Jr. School and the Wentworth Institute, to mention no others. But neither

the corporation school nor the private trade school can be provided *everywhere,* while the public school is always available and can be adjusted to the needs of the public, which owns it, whenever the public so desires. Furthermore there are certain phases of the work which can never be done outside of the public school.

The private schools, almost inevitably, will interest themselves in the training of the non-commissioned officers or even the lieutenants of industry, but the public school, while it has done much good work in this branch of education, has the more difficult problem of training the rank and file of the industrial army. Your committee maintains that such training is fundamentally important even to industry itself. We also believe that the duty to promote such training rests jointly with the schools and the industries.

At this point there will come to the minds of many of us the oft-repeated statement that the schools are unfit for the task—that they have made a failure whenever they have attempted to give practical education of any kind. In reality the failure consists in this mainly, that many schools have, even yet, changed but little from the leisure-class ideals which were rightfully theirs a century ago. Where the public school has earnestly sought to provide truly appropriate education for *working people* they have generally succeeded quite as well as the corporation school. Your duty is to see to it that the public schools *do* address themselves to that particular piece of work, and none can do that more effectively than a great national association of employers.

One thing more should be said about the charge that the schools have failed. Frankly they have succeeded in what they have tried to accomplish. The school is, or has been until recently, a selective agency. It has sought out and advanced the fit, and eliminated the unfit, according to its own standards. Furthermore you seem to have some regard for those standards since industry itself is today trying to attract to its service the best product of the schools, that is to say, those who get the most thorough and extended schooling. In other words the industries and the schools have worked hand in hand.

The schools are criticized because they fail to attract, to hold, and to train the *less able* or even the *least able* among the youth of the land. Frankly, what are your industries doing to attract, to hold, and to train any but the most able you can possibly secure? To the untrained and uneducated they offer little. Thus the schools and the industries have, together, produced a condition under which few young people seek industrial labor through deliberate and intelligent choice. It is said that children are forced into industry. Dr. Felix Adler says they are "pitchforked" into industry. And so it happens that the ranks of industry are recruited mainly from those who are driven into it by poverty, ignorance, lack of ambition, or cupidity.

What fierce, competitive campaign do you expect to win with an army recruited in this way? Would not the future of American industry look brighter if at least a saving minority entered the lower grades of industrial work because they *chose* to do so, and because they saw in such work some opportunity for progress? As a matter of fact neither the school nor the industry has done what it might, or what it ought, to develop industrial intelligence, industrial interest, and industrial ambition on the part of the youth of the land. Both are sinners in this matter, both have been blind, and it ill becomes either to criticize the other for the lack which is now clearly apparent to all.

How Can the Association Help?

How can the American Foundrymen's Association help in this emergency? That is the question which the committee set itself the task of attempting to answer.

We have said that industry can not do it all. The school has a part to perform. The pupil must have an industrial ambition awakened before he leaves school to go to work. He must have a desire for more training and more knowledge. He must be shown that night schools and various other forms of continued education can help. All this clearly belongs to the school to do, but after that *you* must take a vital interest and must play an active part in still further stimulating that industrial ambition. Frequently, working conditions stifle rather

than quicken interest and initiative. You can change all that measureably and you can induce the schools to change their ways also.

The schools have upheld the idea that a *good* education would enable one to get a living without work, or at least without laborious, manual work.

The industries have helped in creating this impression by giving the superior positions to those trained by the schools and colleges. In relatively few instances today are they working to advance to positions of responsibility and high salary those who enter, as in the old days, *at the bottom.*

Your committee believes that the time has come when the school and industry must modify their practices, and when both must work together to improve, to elevate, to educate the *industrial worker*—the hand worker—the machine tender. This the public school must do if it hopes to retain the respect of the people at large, and this any industry must do eventually if it is to keep up in the race, for it must look well to its human factors.

Industry, by means of science and invention, has improved processes and the automatic machine well nigh to the limit. By efficiency engineering it has developed organization almost to an exact science. But what has it done to improve the material or the temper of the human cog in the machine?

Welfare work and the *safety first* movement may be offered as examples of industry's interest in the worker, but are they really so? When the law made accidents a charge upon industry, industry developed an interest in the health and safety of the worker. When industry fully realizes what it is losing through the ignorance and the lack of ambition of employes, may we not hope that an equal interest will be developed in the industrial education movement?

High Wages Due to Disgust, Not Skill

Do not manufacturers generally feel that they are paying more for their lower grades of labor than such labor is really worth, and are not the manufacturers usually right? That is to say, ought not these workers to do more and better work for the money they receive? A well-known economist has pointed

out that the relatively high wages of the low-grade industrial employes are due not to the skill, but to the *disgust* of the workers. The pay is the only thing about his job that the worker likes and the employer has to make that sufficiently attractive to hold him, otherwise he throws up his job on the slightest excuse. In fact he throws it up as it is, altogether too often, another item of unnecessary expense.

Now if the American Foundrymen's Association helps in the development of the right kind of industrial education, will not industrial education, on its part, amply repay the American Foundrymen's Association for its interest? That at least is the belief of your committee and this belief formed the basis of its work, and prompted it to make the following suggestions and recommendations.

Suggestions and Recommendations

We recommend that the Association use its influence to help on the general widespread movement for a better and more appropriate education for the future industrial workers of the country. This movement is rapidly taking form in the public schools and the immediate influence of such bodies as the American Foundrymen's Association is needed to insure its proper direction and its permanent success.

We recommend that the Association seek to induce employers' associations to make definite requests of their local school boards for the establishment of evening courses and to give such boards specific suggestions regarding the content and method of such courses. Evening courses organized at the request of the employers stand before the community in a much better light than those proposed by some educational enthusiast.

We recommend that the Association urge its members to look carefully into the possibilities of co-operative courses and to acknowledge the value of such a co-operative plan by permitting the younger employes to be absent from work for a limited time for the purpose of receiving practical training. Such training will benefit both the employer and the employe and they should both contribute what they can to its success.

We recommend that members of the Association seek to

co-operate, wherever possible, with private endowed schools already in operation. There are many so-called "Mechanics' Institutes" in various cities which are doing far less than they might to improve the education and training of workmen. One reason is that the employers, as a rule, show so little interest in the opportunities presented by these semi-public institutions. We suggest that members of the Association make a definite effort to learn about any such institution in their vicinity, and try in every reasonably way to improve its work, first by commending it to their employes, and second, by making suggestions as to courses of study, organization, etc.

We recommend that the association attempt to work out a plan, common to the whole industry, whereby the attendance of workmen at evening schools will be stimulated and suitably recognized and rewarded. It is believed that a slight monetary reward would bring advantage to both employer and employe.

Employers Aid in Organizing Courses

We recommend that the Association develop plans for taking an active part in organizing courses which will be appropriate for workers in the industry for which it stands. It is no easy matter to determine the nature of the material which should be presented in trade and industrial classes and the intelligent aid of the employers or of the officials representing their interests, is essential to genuine success.

We recommend that a committee of your own members be appointed to consider seriously the possibility of carrying out one or more of our suggestions. Such a *pushing* committee could be of immense service in actually doing the things of which our present committee can merely talk or write.

Our committee hopes that it has been of service in two ways, first by bringing you information from the educational world regarding the widespread and genuine interest which the public school now manifests in industrial training, and that there is progress in this field as in all others; and second, by calling to your attention various possibilities of co-operation between your Association and the educational forces.

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Regarding the first point we would say that school men have shown that they are willing and glad to inaugurate any kind of educational work which the public wants and for which it is willing to pay. There are wide-awake superintendents today who would heartily welcome any demands upon the system if you will make those demands in a spirit of friendly co-operation and will show a willingness to assist in the new venture.

Preliminary Investigation

Regarding the second point, the possibilities of carrying out some of our suggestions, it may be of interest to you to know that a small, preliminary investigation has been made by the committee. Under the authority of your President we sent to 50 members of the Association a letter setting forth, essentially, the recommendations given. Two questions were asked concerning each point:

"Have you ever attempted such action as this?" and

"Do you think the plan feasible?"

The letters were sent out about July 1, and this report was written about Sept. 1. At that time 18 replies had been received and I have tried in the following summary to give you some idea of the attitude expressed by those who were interested enough to put themselves on record:

1.—The first question related to the proposition that the employer, or an employers' association, request the public school to establish and maintain some particular industrial course in the evening schools. Of the 18 replying, three had attempted such a plan, and 17 thought it feasible; one did not.

2.—The second question related to the possibility of establishing day co-operative classes, the employer releasing the employe for a limited time each week for the purpose of receiving practical training in the school. Of the 18 replying, five had attempted such a plan, and 16 thought it feasible, while two did not.

3.—The third question related to co-operation with endowed private schools of trades or mechanics institutes. Three had tried the plan, 16 believed it feasible, and two did not.

4.—The fourth question related to the possibility of having the employers take a leading part in planning and advising courses of instruction for young foundrymen. Five reported that they had tried the plan, 17 believed it feasible, while one did not.

5.—The fifth question related to the possibility of developing definite plans for inducing workmen in the industry to attend evening classes, and of ascertaining what kind of education they wanted and would take. Of the 18 replying, eight had attempted such action, while all believed it feasible.

Extracts from Replies

One letter fairly represented the whole group. The writer said:

> We are heartily in favor of working in connection with the Public Schools *in some way* to further the education of the coming mechanic

Not one of the writers was wholly opposed to the proposition that the public schools should be called upon to help, at least, in giving industrial education to foundrymen. I will quote from four replies which were the *least* encouraging.

One, referring to the part time co-operative plan said:

> We do not think the plan feasible as we believe that practical instruction should be given in the shop itself and not in an outside institution.

Referring to co-operation with private trade schools or mechanics institutes, the same writer said:

> We have attempted no such action. We believe that such schools should only be used for theoretical instruction and not as trade training schools.

He said further:

> We believe that it is a serious mistake to try to teach boys or workmen a trade except in a shop run for commercial purposes. Public and private schools can be usefully employed in imparting such theoretical information to the men and boys as will be useful for them in learning their trades in shops, but we believe that any attempt to take out of the shop and put into a school the actual handling of material is a serious mistake.

At the same time this writer considered feasible our first and fifth propositions, namely that the public school be requested to establish suitable evening courses for foundrymen, and that the employers make specific plans for inducing the men to attend. It goes without saying that we do not concur with the opinion expressed in the above quotation.

XUM

Another writer is somewhat pessimistic, but is anxious to learn of any successful efforts made by the Association in promoting industrial education. He said:

Our investigation of this subject in conjunction with conditions prevailing at our own plants has demonstrated considerable difficulty exists in inducing our men, who are largely foreigners, to take up such courses and classes as we have arranged for in our own settlement or welfare houses, these classes being poorly attended, the men in most cases being illiterate and disinclined to put themselves out to attend, even if only to learn reading and writing.

Several of our plants are located in small places, and it would be exceedingly difficult, if not impossible, to induce the school boards in small communities to make appropriations and provide facilities for evening classes, although we fully believe that such instruction would be advantageous, and we would be willing to do anything possible to accomplish this. In the larger cities something might be accomplished in this direction, either by the public schools, or by privately endowed institutions, as suggested in your letter, and we would be pleased to learn of efforts made by the Association in securing such facilities. We should also be glad to learn of results of the Committee's work in this matter, also regarding the planning of courses appropriate for the workers in the foundry industry.

More to Learn Productive Occupations

Another writer says:

Considering the country at large, we believe that the average board of education would not properly respond to this movement, but that work will very largely have to be done by representatives of industries.

Our feeling is that in any community where there does not already exist an effective organization for industrial education, the first step should be to lay out a course which would assist boys and girls in selecting a definite trade and would interest them in the proper way to learn a trade. The effort, as we see it, should be made to get more people to learn productive occupations rather than to teach those who are already in such occupations more about their own particular line of work.

Another said:

In this city we have for the past few years endeavored to stimulate interest in evening classes along lines of chemistry, mechanical drawing, etc., but it has seemed impossible to secure the number of students to warrant carrying on the work.

But he adds:

We wish to assure you that we are in hearty accord with the general plan and would be only too glad to see more interest along educational lines among the employers.

Suggestive Statements from Replies

A number of suggestive statements were made of which the following are typical:

It has been our experience that, as a general rule, local boards of education are glad to establish an evening course for foundrymen, covering the technical side of foundry work, providing a sufficient

number of men signify their willingness to take up such a course. In S....., the school board will adopt any subject requested should there be ten or more applicants interested.

Our preference in the matter of training foundry apprentices is to conduct a school of our own, rather than co-operate with the public schools. It has been our experience, except where instructors are practical men, their teaching is apt to be very theoretical and their methods less adapted to teaching working boys. We have had good success in our evening school, but believe that better results would be obtained if such school could be had during working hours. This change is now being considered.

There is no question but what good results could be obtained by encouraging foundrymen to attend evening schools, particularly where courses are prepared for their special benefit. We know that the evening technical school of N..... has conducted successful courses for foundrymen for a number of years past.

As far as I can learn, while there is a great deal being done in the technical schools here in this city in the way of night courses and continuation courses, there is nothing being done for foundry work.

Our apprentices are required, under one of our state laws, to attend school five hours a week without loss of pay, the school being held in working hours. Our departments have 50 apprentices working under this provision, about five of them in the foundry. Our management think that this school is of particular importance to them and the courses of study, other than the prescribed studies, are worked out by the director of the school together with our supervisor of apprentices.

The director of the school keeps in touch with the work of the men in our shop and endeavors to fit the courses to their needs. The teachers in the night school courses, with few exceptions, (and those in the academic subjects) are shop men.

I have come in personal touch with a great many educators, and I am very sure that they would welcome and gladly cooperate with manufacturers, if the latter would only move and manifest real interest, and actively help in working out the problem.

We would say that your proposal is quite in line with what we have been attempting to do for some time.

We have an apprenticeship arrangement of our own extending over two years, *but it reaches only a comparatively few of our younger men* who are being trained for positions with the company. To your various questions therefore we are obliged to reply no in every case, meaning that we have not attempted any of the things you have suggested.

We think all of your suggestions are feasible and well worth trying; they will all help toward a proper agitation of the question. After all we will never get a proper industrial education system in effect in this country until there has been aroused more general public interest in the question than there is at the present time.

Properly educating our people in this country should be a government function, and the state and city schools should feel a larger responsibility. In this connection I am very glad to note your questions intended to bring out the duties of boards of education along some of these lines.

This company is glad to do all it can as its share. A company official is on the board of education and the plan of evening classes has been nicely worked out.

Summary

In concluding this report let me sum up the situation in five brief statements:

First, industrial education means a complete scheme of education for the industrial worker, not alone the shopwork, but all other phases of his training which will add to his efficiency.

Second, it is your privilege to determine just what you would like your foundrymen to know and to be so far as education is concerned.

Third, it is also your privilege to make a demand on the schools to co-operate with you in producing the kind of man you need and want. While the demand may be made in the friendliest spirit, it may still be a demand.

Fourth, it is your duty to cooperate with the schools, by giving advice and information regarding the organization of the classes and the subject matter of the courses of study.

Fifth, if industrial education does not make your employes more efficient we do not want industrial education. If it *does* make them more efficient you will reap the benefit, or at least some of it and should, therefore, be willing to share in its support, not necessarily by direct payment to the school, but by concessions or rewards to the workmen who spend their own time following the courses which you have helped to organize and which you approve.

FRANK M. LEAVITT, CHAIRMAN.
Arthur Williams, New York City.
Clifford B. Connelley, Pittsburgh, Pa.
E. A. Johnson, Boston, Mass.
Lewis Gustafson, St. Louis, Mo.
C. E. Hoyt, Chicago, Ill.
Paul Kreuzpointer, Altoona, Pa.
Committee on Industrial Education.

NOTE:—The majority of the members of the committee approved the recommendations submitted to the members of the Association, but the report, as a whole, has not been submitted to the committee. The chairman understands that he has the right to present the recommendations in this manner.

Discussion—Industrial Education

MR. FRANK M. LEAVITT:—As you know, the report of the Committee on Industrial Education is in print. The purpose of my remarks, at this time, is primarily to attempt to convince you that the public schools are competent to deal with many of the problems of industrial education, or may be made so with your influence and co-operation.

About 30 years ago I worked in a foundry for a short time and today, as I looked at the various exhibits I said to myself, "What wonderful changes have been made in the foundry business in 30 years!" What I want to do now is to convince you that there have been just as great changes in the public schools during this time as there have been in the foundry business. I am attempting to do this because when I ask you to place some reliance on the ability of the public schools to give industrial training, I know that many of you will be inclined to believe that the public schools do not know anything about it and, therefore, are wholly inadequate; so I want to convince you that the schools have changed as much as the foundry business in the last 30 years, in order that you may not judge schools by old standards.

I want to comment briefly on two or three points in the report of the committee. In the first place, I understand that this Association is not primarily concerned with labor problems, that you are not especially interested in putting the American Federation of Labor out of business, but rather that you are interested in the technical and scientific phases of the foundry business. I want to convince you that industrial education is one of these technical and scientific phases of the foundry business. If it is not, your committee has no interest in it.

The question is, "What are you going to do to improve the quality of the lower grades of labor that you are employing?" Anybody can tell you what to do with labor at the

very end of the scale. For example, you can reorganize your corporation schools. I know something of these schools and they are all right as far as they go. But you know, gentlemen, that corporation schools are not interesting themselves very much in the lower grades of labor. In fact there is little in industry today to make it possible for one who enters it on the lowest round of the ladder to climb up through as a boy could have done, say 50 years ago. On the other hand, business men criticize the schools because these institutions are not willing to do all that they should for the lowest grade of students who attend them. What you should know is the fact that the very thing you criticize the schools for, you have helped the schools to become, namely an organization for selecting the better and the best from the mass of pupils.

Let me show you what I mean. A certain educator once said that when he was in college a certain history class came back after the mid-year examinations much reduced in number, and the professor addressed the class as follows: "Now, gentlemen, I am glad to say that I have in front of me a group of men whom God intended to study history." The professor in the meantime had been reading the papers and helping the Almighty decide which of these men really were intended to study history. Now it is true of most schools today that the chief business of the teachers is to help God to determine important questions in regard to the future educational opportunities which his pupils shall be allowed to enjoy. The sixth grade teacher is trying to find out what God's will is regarding the question as to whether his children shall or shall not have a seventh grade education. Similarly, the high school is trying to determine whether its students shall have a college education or not. The point I would try to make is that business has helped the schools in maintaining this attitude toward education, since business employers quite generally today differentiate their employes according to the amount of schooling which they have received.

For example, I know of one corporation school where there are three grades of apprentices. Two or three of the pupils are graduates of Cornell University. A somewhat larger number are high school graduates, while the majority

are elementary school graduates. While all these young men are in the same apprenticeship school, they were being trained for three distinct types of work. The college graduate for certain administrative jobs. The high school graduates for non-commissioned offices of the industry, and the elementary school graduates for the rank and file. Therefore, I say, that when it comes to this question of selecting the best and of eliminating the rest, I do not feel that business can blame the schools or that the schools can blame business. Both educators and business men are now coming to see, more or less clearly, that private industrial education is essential for even the lowest grades of labor.

Further, schools are coming to see that by eliminating the unsuccessful students they are sometimes losing their best material. One of the foremost technical colleges eliminated a certain man 15 years ago, who wanted to be a mechanical engineer. They told him he did not have the right qualifications for that work. Today he has an international reputation as a mechanical engineer, and the college which eliminated him has asked him several times to come back and accept an honorary degree. It is obvious that in doing so, they would only honor themselves. When the degree would have been of some use to this struggling young man, they withheld it because he could not do certain stunts. If this sort of thing is bad in an endowed institution, it is far worse in a public school system. What we need is something to wake the educators to this fact. As I walked through your exhibit, I noticed a piece of machinery labeled "jolt-machine", and I thought as I looked at it that something analogous to that was needed in the educational world, and I believe that your association and similar organizations are better equipped to do us that service than is any other agency.

Not all the public schools, however, are conservative and asleep. Some are waking up and they appreciate the fact that their chief business is not selective, but rather is distributive. If we have 10,000 people entering the public schools, it is obvious that these people will ultimately go into many different kinds of occupations and that it is the business of the public schools to minister to the educational and social needs of every

one of these pupils. The old-fashioned notion was, and one might say the conservative notion is, that it is dangerous to put industrial education into a school because it may prevent some of the boys from "going on". The progressive schools, however, will say that all pupils are going on somewhere, and that it is the business of the public school to help them all into the place where they can reach their greatest usefulness and their surest success and happiness. I cannot go into the details now, but I could describe to you a progressive public school system that does not forget one single child, or at least, it does not forget one single class of children in the whole community. There are 13 different high schools, and I might say that those 13 high schools are all different. I know of another city where they have six high schools which they affirm are all exactly alike. But we know that the children in that community are not all exactly alike; they have different capabilities, different interests, different destinations, and yet those public high schools are *all* alike.

Furthermore, few get into the high school and fewer graduate from it. In almost any community you will find that there are six to ten times as many children in the sixth grade as there are in the last year of high school. In Cook county, Illinois, there are ten times as many children in the sixth grade as in the last year of the high school. In the state of Illinois there are eight times as many; and in the state of Indiana, there are six times as many. Now I want to tell you what I think you ought to do. The public schools belong to the public; they do not belong to the select few who are going up through high school or college; it is your right as business men in a community, to go to the board of education and demand that that board of education establish some sort of training that will do something for the lowest grade of labor that you have, if that is what you want. I am not quite sure that is what you want. Most business men, as I know them, are perfectly satisfied if the public schools will do something to train the non-commissioned officers and the colleges will do something to train the people who are to work in the administrative departments of the business, and they

are not asking very much for the people who are down here in the rank and file.

Do you realize that today there are almost no young people going into industrial work unless they are driven into it? There was a time when a boy would say, "I want to be a mechanic, I want to work with my hands, I know there is something in it for me." But would you send your boy at 15 or 16 years of age into a shop? Perhaps you say, "Yes, I would, but I will look out for him, I will see that he gets up through;" if you were not in that position you would say, "send him to a shop? Not on my life. I will send him to school as long as he will go, because the longer he goes, the better chance he has to get at the good things of life." So those who go into the industries, go because they are forced in by poverty, lack of intelligence or lack of ambition. When you read the report of the Committee I hope you will feel that the Association ought to devise some scheme whereby you can induce the board of education to establish night schools, if nothing else, to which you operatives can go for the purpose of developing in them an interest in the business and an ambition to succeed in it.

You ought to help the boards of education to organize the right kinds of schools. How can teachers know what to teach to future apprentices unless you help them? But there is also another side to the question of stimulating these young and uneducated employes. An employer occasionally starts a night school in connection with his plant and calls it "welfare work", and then complains that these *ignorant* foundrymen do not know how to make your employes *want* a good vocational education or training. It is a science and an art to know how to take uninterested people and make them study, or as some one has said, "to take indifferent people and make them *different.*" That is the school teacher's art and you must rely on the school teachers and on the public schools in a great deal of this inspirational work. The schools cannot do it all and you cannot do it all, there must be co-operation.

The public owns the public schools and you have the right to demand of the boards of education that they do something for the boys who are to go into the industries, and you have also

the privilege and the duty to help them do it because you have the information. In brief, you have the right and the duty to see to it that the public schools are so made over that they will do the best in their power for everyone who goes to them.

THE CHAIRMAN, MR. R. A. BULL:—I know that Major Speer has followed the matter of education along technical lines in Pittsburgh very closely, that he has been very much interested in it and I have no doubt that he has some very good thoughts along the line suggested by Mr. Leavitt's remarks. Would you care to say anything, Major?

MAJOR JOS. T. SPEER:—I am sorry you called upon me, because I don't think I am capable of expressing any opinion on the subject. Mr. Seaman and I were called in by the Carnegie Institute of Technology in Pittsburgh, in which was spent a vast amount of money, and we got interested in the foundry end of it. The Carnegie schools today are carrying out the thought of the former speaker. They are putting into practice the education of the foundry end of it, not only the boys, but they have on their enrollment foremen, assistant foremen and superintendents of foundries in the Pittsburgh district. When Director Hamerschlag came to Pittsburgh, he was a stranger to all of us, and to me he is one of the most wonderful, theoretical men who could be had as director of the Institute. He will tell you, as he told us at that meeting, that he knew nothing about the practical end of foundry work, but he knows a great deal about the technical end of it. He assembled the experienced foundrymen of Pittsburgh into a committee, called Mr. T. D. West to Pittsburgh and said, "What do you foundrymen want in the way of a foundry? Mr. Carnegie is going to furnish a foundry complete, and will give you all the machinery, cupolas and everything of that kind. You tell us what you want and it will be furnished." After several conferences we decided on a line of what was actually needed and they have got today—and are enlarging it, by the way, to double its capacity—a complete foundry where they take these boys and these men at night and give them a practical knowledge of foundry work. If they care to go further, they take up chemistry, give them a fair knowledge of iron, chemical analyses and demonstrate molding methods. I think, today, it is the

most complete foundry in the world in any educational institution. They started out without text books, but are making their own. I have had some experience with boys who have been working during the day and going to school at night and I would like to hear from "Daddy" Seaman about one man especially that he has in his employ and the experience he has had with that school. It is all right for theory, gentlemen, but you want to try to educate your boys along practical lines.

MR. J. S. SEAMAN:—I am not accustomed to say much on subjects of this kind, but as my friend, Major Speer, has called on me to give an instance of the Carnegie School, etc., I will give you an illustration of what happened in my own foundry. I will not mention the young man's name, but he came there as an ordinary laborer employed in the yard, handling pig iron, a man possibly 6 feet 2 inches tall, and a fine specimen of manhood. About that time, we were engaged with Mr. Hamerschlag in reference to establishing the foundry school and it was just about completed. My man came into my office one day and said, "Mr. Seaman, do you know whether I can get into the Carnegie Technical School?" I told him, "Do you want to go?" "Yes," said he, "I want to go there." I took up my phone and called Mr. Hamerschlag and he told me to send him over, which I did, and he entered the young man in school. This young man worked all day in my foundry—he was promoted to the cupola class—and went home in the evening, changed his clothes and went over to the Technical School, which was possibly five or six miles; he went every night except Saturday and Sunday and took up chemistry, which was what we wanted, as we work largely by chemical analysis in our place. He was there three years and graduated. He is today in my employ and I consider him the best man for the position that I have ever heard of. He was a poor boy when he came to us but he got a chance. I think there are a great many boys who, if given an opportunity to study, could equip themselves for better positions. This young man today is a stockholder in my company and is doing very well.

DR. RICHARD MOLDENKE:—The address of Prof. Leavitt has just struck the right thing, in my opinion. Our public schools should not attempt to make finished foundrymen; they

can only make men fitted for mechanical pursuits in general, and consequently the education there should perhaps be more of a general nature, aiming eventually at mechanical trades rather than specializing. I have called the attention, again and again of our several committees on the subject, to the fact that unless the foundrymen, or other manufacturers, go to the public school authorities, lay down a program and say, "This is the thing we wish accomplished", all our talk and resolutions will vanish in thin air. We want a definite program of the things our boys should study and then the board of education probably will say, "This is a little too specialized, we will give it to you in a more general form". We want the man who stands over a lathe, or who is pounding sand, to know why he does what he is doing. We don't want to make finished mechanics, for that is not the function of the public schools; but we want to educate the boys to think for themselves so that they can then go out and work afterwards, not just for the pay, but to develop what is in their brains and know what they are doing and why they are doing certain things. Until we go to the schools with a definite program, I think we are wasting much of our time in idle discussion.

MR. FRANK M. LEAVITT:—With reference to that point I wish to say that it is exactly what our committee feels this Association ought to do. I think it would involve a little work and possibly some expense, but I really believe that this Association might get out a program, as you say, which could be put into the hands of every member of the Association to guide that member, in his own community, in his demand on the public schools. Not only the Carnegie Institute, but other schools of that kind, notably the Wentworth Institute at Boston, are doing work for foundrymen. I talked with the man at the head of the foundry department of the Wentworth Institute only last Sunday and he recited many instances of relatively ignorant young men who were uninterested and unprogressive until they got into his school. Then they developed an interest in the "Why" as you say, the chemistry of it, and the worthwhileness of it all, and then had gone ahead and progressed. Now I hope that if nothing else comes of the work of our Committee, this Association will take some action looking to the

outlining of a definite program which can be put up to the public school authorities throughout the country wherever there is a member of your Association. In the preliminary investigation our committee made—you will see an account of it in the report—there was an indication that many foundrymen would like to have such a program worked out, that they believe it is feasible and would use it if it were available.

MR. B. D. FULLER:—I wish to say, in line with Prof. Leavitt's remarks on the change that is taking place in public school education, that at home (I happen to be a member of the board of education of Lakewood, O., and connected with the Advisory Committee of the Technical Schools of Cleveland) we have two technical schools, known as the East and West Technical schools of Cleveland. We have a commercial high school and six or seven academic high schools. Almost 50 per cent of the boys and girls that graduated from the eighth grade and are attending high school this year went into the technical schools, the balance into the seven or eight other schools. There is a very lively interest in technical school work. A movement is on foot in Lakewood, where I live, to build a new high school. We intend turning the present high school into a technical school. The idea is to separate the children, after they have reached the sixth grade in the public schools, and have them go into academic technical or commercial training. I mention this as an indication of the change taking place in public school education, believing that it bears out what Prof. Leavitt has said.

THE CHAIRMAN:—I think it is obvious to all of us that the men in this Association can do a great deal in making that change more extensive and in bringing it about more quickly.

MR. W. H. BARR:—I have been very much interested in this discussion and I would like to point out, for the benefit of your committee and perhaps for the members, a line of action that has been attempted by a number of national associations along this very line, attempting to plan, if you please, this broad policy of education for the type of pupil which has been discussed. Recently, we organized in a national way, a conference board of industrial training. It is composed of the presidents and two others of these five associations: The

National Founders' Association, the National Association of Manufacturers, the National Metal Trades Association, the National Machine Tool Builders' Association and the United Typothetae and Franklin Clubs of America. The latter have done excellent work. The conference board was organized to establish effective co-operation between employers in the training of employes for the industries and to impress upon employers their peculair responsibility for the training of their employes, particularly minors, based on co-ordinated trade training and technical class room instruction; to devise plans and make recommendations to employers for the accomplishment of this purpose and to co-operate with all educational agencies, public or private, which properly correlate craft training with class room instruction. If our plans work out it will, I think, be entirely possible to offer, at a future date, this method of instruction that seems suited to the broad training of apprentices, and on behalf of this conference board, I would like to invite this Association to be represented thereon by a committee composed of the president and two others, at our next meeting within three weeks. It is possible, through a broad spirit of cooperation, to develop results that no one association could in itself. I offer that thought, Mr. Chairman, and would be glade to answer any questions that the committee may be pleased to ask in reference to it.

THE CHAIRMAN:—On behalf of the Association, I want to thank the conference board which has extended this invitation for co-operative work through Mr. Barr; and I suggest that as the time is short, the matter be presented for perhaps some extended discussion at our Wednesday night session, unless there are some present who think they will not be in attendance at that time.

JOHN H. COCHRANE:—At York, Pa., a plan of industrial education is well under way, as a result of co-operation between the Manufacturers' Association of that city and the school board. Classes have been formed in foundry, machine and pattern shop practice and other work, the boys being required to serve a certain period in school and shop before receiving their certificate. They alternate one week in school and one week in the shop until the course is completed. In school they are

addition, they are paid for their shop work. This encourages the boys and a majority of them take a real interest in their facturers' Association, York, Pa.
taught, among other things, how to read and make drawings, while in the shop they are taught how to apply their knowledge. By this scheme they are given an opportunity to learn, and in work. Those desiring detailed information regarding this course can obtain it from Robert E. Gephart, secretary, Manufacturers' Association, York, Pa.

The Oil-Fired Cupola

By Bradley Stoughton, New York, N. Y.

When I accepted the invitation of this Association to prepare a paper on this subject, I expected to have to present to you the results of a very extensive test of the oil cupola, so that the remarks that I should be able to make would have some scientific as well as practical value; but unfortunately, it proved to be impossible without interfering with the operation of a very busy plant to carry on such an extensive test as I wished to have. Therefore, the results I shall give you will be only results of practical operation, though I would like to have had them more than that.

History of the Process

The question of using fuel oil in a cupola, or crude oil in a cupola, occupied my attention a good many years ago, and I then made my first description of the process, but it proved to be necessary to experiment quite a little bit with this process before I was able to get results that were successful in the technical and commercial sense. I might say that the first tests were made for me by Dr. Richard Moldenke in the cupola at his castle in Watchung, N. J. That is now some years ago, and these were followed by some tests made at an abandoned foundry, in a cupola which we fitted up for the purpose. Last March we made our first commercial installation, and, since that time, the process has been in use continuously in a foundry, and such results as I can give you are chiefly the results of that work. (See illustration, page 527.)

At the very start I discovered that one could not melt iron in a foundry cupola without coke, because the melting mass would mat together, and, furthermore, it became known to me that one cannot burn oil efficiently without some extraneous source of heat; that is to say, strange as it may seem, oil will not efficiently burn itself completely. Starting from these

premises, I devised the form of cupola shown in the accompanying illustration, which consists really of an ordinary cupola with four ignition chambers, *C*, situated about the level of the tuyeres and into which is sprayed atomized crude oil, together with air to burn it. Underneath each of those chambers is introduced, through a small tuyere, *D*, a slight amount of air unmixed with oil. These are the only respects in which the oil cupola differs in design from the ordinary cupola; in fact, it has been customary with us to change over an ordinary cupola merely by adding these ignition chambers and the little tuyeres underneath.

Cupola Bed

To operate the cupola, it is first filled with coke up to the melting zone, as usual, and then the iron is placed on top of this bed. It is necessary that the coke bed should be kept red hot all the time by its own combustion, but that combustion is very much less than the coke combustion in the ordinary cupola, because we do not want the heat to melt the iron, we merely want sufficient heat to maintain that bed at a good, red color. Even this small amount of combustion, however, would exhaust the bed if it were not replenished and, therefore, we mix with the iron, as it is charged, a small amount of coke. This coke is much less in amount than that charged in ordinary cupola melting, and is only one-fourth as much, or less than one-fourth as much. As I shall explain later, we can control the combustion of the bed by controlling the amount of air introduced in the tuyeres underneath the ignition chambers. This air is very carefully regulated by separate valves situated at each small tuyere, and is controlled to the point where the least amount of air is admitted that will maintain the coke bed in a state of bright incandescence.

If one directs the flame from burning crude oil upon an incandescent mass of coke, the oil flame will actually quench the coke fire and bring it to a state of blackness, but I avoid this quenching by maintaining a slight combustion of the coke bed, sufficient in amount to keep it in an incandescent state in spite of the quenching effect of the oil flame which is directed upon it, as will be described later.

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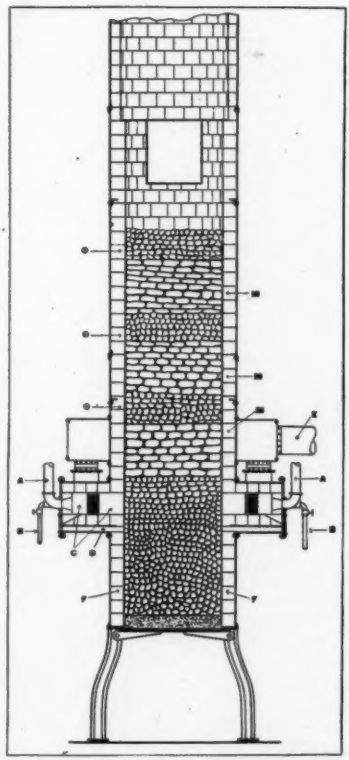
The oil is introduced into the four combustion chambers in atomized condition, and is there mixed with the proper amount of air for its complete combustion. Ignition begins in the ignition chambers and the oil flame then comes in contact with the incandescent bed of coke in the cupola. This incandescent bed of coke acts as a catalytic agent to complete and intensify the combustion of the oil; and, furthermore, the burning of the coke bed supplies that extraneous source of heat which enables the oil to be burned efficiently and completely. The gases from the oil and coke combination rise through the red-hot coke bed to the melting zone and there melt the iron. In this phase the melting operation is exactly the same in effect as if the red hot gases which do the work were obtained from coke alone, as in the ordinary process, instead of being obtained from both coke and oil. In the practical operation of the process it has been found that the melting can be regulated by regulating the amount of oil introduced, so that we can get a hotter or cooler temperature as desired.



CROSS-SECTION OF OIL-FIRED CUPOLA

A.—Air for atomizing oil.
B.—Oil-supply pipe.
C.—Ignition chamber.
D.—Tuyere for admitting air for combustion of coke.
E.—Main blast pipe.
F.—Coke bed.
M.—Charges of iron for melting.
O.—Supplementary coke charges.

The results of commercial operation so far show that we can replace with oil practically three-fourths of the coke ordinarily used, and that good, hot iron may be obtained with 60 pounds of coke and 7¼ gallons of oil to the ton of iron melted. This does not include the coke used in the first instance on the bed, which is, of course, the same as would be used in the ordinary coke-melting operation.

Control of Combustion by Controlling the Air Admitted

I have also discovered that when oil and air are mixed and admitted, as previously described, on to the red hot bed of coke, the air will unite by preference with the oil and will not attack the coke. It is, therefore, possible to obtain perfect combustion of the oil by admitting just the correct amount of air for that purpose. It is also possible to exactly control the combustion of the coke bed by regulating the amount of air admitted through the tuyeres underneath the combustion chambers, this air alone being available for coke combustion. In this way we can burn the minimum amount of coke necessary to maintain the bed in an incandescent state, and can do the maximum amount of melting work with the oil. This control of the combustion of the coke by means of controlling the air admitted to burn it is very important, because it has been found that the amount of sulphur absorbed by the iron is largely dependent upon the amount of coke burned. In other words, the less coke we burn, the less sulphur will be absorbed by the iron.

Sulphur Absorbed

We believe that the most important advantage obtained in the oil cupola is the small amount of sulphur that is absorbed by the iron, and we have made a few tests on this point. The first test made was at an experimental cupola of 42 inches diameter inside the lining. In this case the iron before melting contained 0.010 per cent sulphur; after melting it contained 0.022 per cent sulphur. Later, Dr. Moldenke made a comparative test for us of the sulphur absorption when melting with coke and when melting with oil. He reported on the basis of this test that iron which, when melted with

coke, contained 0.080 per cent sulphur, will, when melted with oil, contain 0.045 per cent sulphur. Another test showed that iron increased from 0.032 per cent to 0.045 per cent, an increase of 0.013 per cent during melting. But, in that case the cupola was melting 50 per cent of its own scrap, so that half of the iron had been melted twice and had absorbed sulphur twice to make a total gain of 0.013 per cent sulphur. A still more recent test showed that a mixture which contained 0.026 per cent sulphur before melting increased to 0.035 per cent sulphur after melting, an increase of 0.009 per cent. It is expected that as we gain experience in the use of the cupola the amount of sulphur absorbed will be decreased.

Kind of Oil to be Used

Crude oil, because it is cheaper in price and of higher heating value per gallon than fuel oil, is preferred. Furthermore, it can be obtained much more readily and is not so dependent on fluctuations in the market, such as, for example, a variation in the demand for gasoline. There are also more large firms able to supply crude oil than can supply fuel oil for melting. In the use of crude oil, however, it is necessary to warm it in some way during cold weather. This can be done very easily with a small gas flame, or by means of a steam pipe, or by means of electricity, as one pleases. It is not necessary to warm all of the oil, but merely to warm the oil as it goes from the tank into the supply pipe, and if this pipe from the tank to the furnace is long, it is desirable to warm it for a part of the way at least.

It is not necessary that a low sulphur oil be used, because practically all the sulphur in the oil is oxidized by the blast and does not enter the iron, but passes out of the cupola with the gases. We have used oils containing 1.6 per cent sulphur and oils with only about half that much without noticing any difference in the amount of sulphur absorbed by the iron.

Discussion—The Oil-Fired Cupola

MR. A. W. WALKER:—I would like to ask Mr. Stoughton what percentage of sulphur his oil contained and if it is not possible that, by the use of a low sulphur oil, he was able to get this low percentage of sulphur in his metal; and might it not be possible to obtain a much higher percentage of sulphur by using an oil containing 1 per cent sulphur?

MR. BRADLEY STOUGHTON:—So far, we have not found that there is any important difference in the results from high sulphur and low sulphur oils. In the first test I cited, which was made in the experimental cupola, the oil contained 1.6 per cent of sulphur, a very high sulphur Texas oil, and in the other test the oil contained about half as much sulphur as that, but we noted that the sulphur is oxidized and burned before it comes in contact with the iron, and our results make us believe that the sulphur simply passes out of the cupola in the form of gas and that the absorption of sulphur depends only upon the amount of coke burned. In other words, the more coke you burn, the more sulphur from that coke will go into the iron, but in any event, using that high sulphur oil, which I believe is about as high sulphur as there is in oil, 1.6, we did not find that there was not a large absorption of sulphur.

MR. A. H. BLACKWOOD:—I am very much surprised to hear Mr. Stoughton talk about using coke at all. If he wants to melt in a cupola with crude oil, why does he use coke? You ash the coke so fast that you burn it down, cut it up. I would like to ask Mr. Stoughton why isn't it possible to use silica brick instead of coke in the same place?

MR. BRADLEY STOUGHTON:—For two reasons: The first reason is that silica brick, and in fact any ordinary brick, is attacked so badly in this zone, that it slags together and also slags off the iron; and in the second place, because it is the red hot coke which makes the use of the oil most efficient. Now, it was my ideal years ago when I started this, to get

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along without coke, but since I have been working with the process and have become interested to read and hear what others have done, I find that a good many people have tried without coke and have failed very badly. There were reported to us, not long ago, tests made by a large firm; they spent something like $40,000 on their various experiments, trying to get a process without using coke, but without success. Very often one finds that "half a loaf is better than no bread", and if you avoid using coke altogether, it doesn't work.

MR. A. H. BLACKWOOD:—I would like to ask Mr. Stoughton how he takes care of his ash from his coke. You get an incandescent flame in there; it burns up your coke so fast that you cannot carry your burden; how do you take care of that?

MR. BRADLEY STOUGHTON:—We do not burn our coke fast; we only burn it a quarter as fast as usual and take care of the ash in the usual way, by slagging it off. We have not had any trouble on that score at all.

MR. A. H. BLACKWOOD:—Don't you increase your maintenance the minute you bring up that heat unit from the oil? Don't you increase the production of ash faster than when you burn coke in the cupola?

MR. BRADLEY STOUGHTON:—The ash results from the burning of the coke; no other ash goes in there; the oil has no ash. We can get, perhaps, a greater incandescence there than the ordinary cupola, if you wish to drive it more intensely, but that does not make any more ash; the only way ash gets in there is that it is in the coke, and we only put in a quarter as much coke.

THE CHAIRMAN, MR. B. D. FULLER:—I take it, Mr. Stoughton, that the introduction of the air through the oil chamber is through a more greatly reduced tuyere area and on a lower pressure than ordinary; or do you maintain the same pressure?

MR. BRADLEY STOUGHTON:—We generally maintain the same pressure of about 8 ounces, but it is a small tuyere and we reduce the amount of air introduced below the ignition chamber to a point just sufficient to keep that coke red hot.

THE CHAIRMAN:—Is the tuyere continuous?

MR. BRADLEY STOUGHTON:—No, the tuyere is simply underneath the ignition chamber, and the four ignition chambers

occupy about two-thirds of the cupola, so that there is one-third of the cupola which is blank in each case.

MR. A. H. BLACKWOOD:—What does the molten iron do to the coke bed?

MR. BRADLEY STOUGHTON:—Well, the molten iron acts on the coke bed exactly as in the ordinary cupola: Trickles over the coke bed, goes out of the cupola and leaves the coke bed behind. I cannot tell you anything else it does to the coke bed except that it absorbs the sulphur from the ash that has been left.

MR. J. H. HOLMGREEN:—Ordinarily it takes 28,000 to 32,000 cubic feet of air to melt a ton of iron; about what is your consumption of air per ton of iron in oil? Are you making any saving either in power or ash?

MR. BRADLEY STOUGHTON:—We are not aware of making any saving in the power used for the air. We are using the same blowers that we used before, when the cupola was employed for regular coke melting; that is one of the important things I was very anxious to test in order to be able to tell you about it, but you can understand that a busy foundry does not want to have tests made in times like these when they are rushing as hard as they can, and it was not fair to ask them; but I am sorry, very sorry that I have not been able to measure that air and tell you how much we are using. All I can tell you is that we are using the same blowers as before.

MR. R. F. HARRINGTON:—I would like to ask what the saving would be over ordinary melting on a 20-ton heat?

MR. BRADLEY STOUGHTON:—The saving, of course, would depend entirely on the price of coke and the price of oil. Coke will run, I suppose, anywhere from $3 a ton, in favorable localities, up to $15.50 a ton in San Francisco and $25 a ton in Alaska, and oil will run all the way from 50 cents for 42 gallons in San Francisco up to $3 or $4 for 42 gallons in other places. You see it is almost impossible to figure. There are other ways on which you can figure a saving than on fuel costs; for example, if you don't care about getting your sulphur very low, you can use a high sulphur iron in the first instance, and we find that some of the blast furnaces will sell iron which is three or four points higher in sulphur at a slightly reduced

price, 50 cents a ton we found in one case; we are now contemplating using a cheaper grade of coke, on the assumption that, as we do not require the coke for heat, but the heat comes from the oil, we can use a cheaper grade of fuel. Then, in one installation which we are now making, they plan to use a very greatly increased proportion of scrap, because their scrap runs high in sulphur and they are obliged to use less of it because their sulphur gets too high. Now they are able to use an increasing amount. All those things have an influence, but every one of them, you will see, depends upon the locality. I can say approximately what it would be in Philadelphia, for example, or San Francisco, for example, or in any other locality we could work it out, but it depends on those factors.

MR. R. H. WEST:—I would like to ask Mr. Stoughton the nature of his charge, whether it is all pig iron or pig iron and iron scrap or pig iron and steel scrap; also if this cupola is in actual operation and how long it has been? I think that will answer the question asked in regard to silica brick.

MR. BRADLEY STOUGHTON:—We have made charges all the way from 100 per cent of pig iron to 100 per cent of steel. We have run for extended periods of time on 50 per cent of iron and 50 per cent of steel scrap, and we have run in other cases on 75 per cent of pig iron and 25 per cent of iron scrap. Now, as regards operations; one of these cupolas has been in continuous operation since the middle of last March, and melted a good many hundreds, in fact, some thousands of tons. I have not the exact figures, but it is in use right along; it is the only way this foundry has of melting its metal, and they melt it right along; use it continuously.

MR. I. B. LESCH:—I would like to ask what the total carbon was when melting 100 per cent steel scrap and 50 per cent steel scrap, to get an idea of what effect it has on the total carbon in the casting.

MR. BRADLEY STOUGHTON:—I might say that when we melted 100 per cent steel scrap, we had our troubles, but I do not believe we should have today. That was in the early experimental stage and in an experimental cupola that we hired for the purpose. We charged soft, open-hearth plates, which is a very difficult material to melt. The first time we

melted about 1,000 pounds, and then the cupola bunged-up completely, partly due to the fact that we had oil troubles and partly due, no doubt, to inexperience. The next time we got along better, melted a good deal more than a ton of steel, but then we burned out the breast. We had made up the cupola with the ordinary sand used for iron work without taking into consideration, as we should have, that steel is a great deal more corrosive, and the steel came through the tap hole and carried away part of the tap hole and then finally carried away the whole breast; so we never did have a full test, but our object in melting the steel was to see if we could carborize it up to 3½ per cent, but we did not carborize it up to any such per cent. The iron we made contained 2.02 per cent of carbon. When we melted 50 per cent iron and 50 per cent steel, the amount of carbon did not differ from the ordinary, but gave melted iron having 3.24 per cent of carbon.

MR. A. H. BLACKWOOD:—I cannot understand why Mr. Stoughton, and he agrees with me too, that when you have so much molten iron running through a coke bed, that the coke don't burn up. We know that in commercial practice, where we use 50 per cent of steel and 50 per cent of iron, that 2 or 3 points of sulphur don't mean anything. If we are going to save sulphur that way, I'd rather flux it with manganese slag in the cupola and take care of it that way, but I cannot understand yet, why, when you have got a cupola of so many inches diameter, start your blast and apply the oil for melting, why you have got to have coke at all. I would like to have Mr. Stoughton tell me why it is necessary to have any coke; that is what I want to know.

THE CHAIRMAN:—I think, gentlemen, in all fairness to Mr Stoughton, we should remember that before he commenced his paper he told us he was not able to give us a technical report of the results so far obtained, but I think that what he has given us has been remarkably interesting and the way he has met all questions is rather surprising. Now whether he can enlighten us on such a question as that, I am doubtful. Perhaps he would like to answer that question.

MR. BRADLEY STOUGHTON:—Perhaps Dr. Moldenke can do it.

DR. RICHARD MOLDENKE:—Most of us who have tried oil have filled the cupola full of iron and applied heat at the bottom. What do you suppose happens? The iron will get red and the heat will go right up into the charge and never will get high enough to melt. The heat is conducted away too fast. If you can insulate a layer of the iron so that the heat has got to remain in this portion and melt it out of the way before it gets to the next portion, you will have some chance. The little opening shown below the tuyeres is a very important feature. If you have applied oil in your cupolas you have noticed that when you put it on you nearly put your coke fire out. The idea of that little extra air below is to just keep the coke white hot, and when the oil strikes it—and by the way, that means oil and air—it keeps burning. Put the coke in as shown and then the oil will do its work. I think I can say frankly that I know of nothing as hot as the limited zone of almost perfect combustion in the cupola. Coke and air make the hottest fire I know of except an electric furnace. I do not think that even the open-hearth makes a fire as hot as that, so the thing to do is to keep the metal charges at point of incandescence in the cupola.

MR. S. D. SLEETH:—Mr. Stoughton, did you ever try natural gas instead of oil?

MR. BRADLEY STOUGHTON:—We have had natural gas in mind and also pulverized fuel, but so far we have not had the opportunity to try anything except oil.

MR. S. E. JONES:—I wonder if Mr. Stoughton could tell us what volume of air is being furnished or entering those small tuyeres just under the oil combustion chamber that keep the coke bed at incandescent or white heat?

MR. BRADLEY STOUGHTON:—Well, we know that we burnt a quarter as much coke as usual, so that it would stand to reason that a quarter as much air as usual entered the coke-combustion tuyeres. In a 42-inch cupola melting something better than 7 tons per hour, we use 420 pounds of coke, and the amount of air used to burn that can be calculated very readily; you see it is 30,000 cubic feet multiplied by 420; that will give it to you approximately.

Thomas Dyson West

In the death of Thomas D. West, at Cleveland, on June 18, 1915, the American Foundrymen's Association lost one of its most loyal members and indefatigable workers, and the foundry industry of the world, one of its most persistent and intelligent investigators. At the time when gray iron practice was largely by rule-of-thumb, Mr. West began to inquire into the causes for certain results and believing that the art could best be advanced by publicity, he detailed, in contributions to the technical press, his experiments and tests. He was the father of American foundry literature, and to the time of his death he maintained an active interest in foundry progress. Mr. West was a member of the American Foundrymen's Association since its organization at Philadelphia, in 1896, and at the annual meeting, held at Cleveland, in 1906, he was honored by election to the office of president. He served almost continuously on various committees of the Society and contributed freely to the *Transactions* in the form of papers and discussions.

During his later years Mr. West devoted a large part of his time to the promotion of the "Safety First" idea, having organized, in 1908, the American Anti-Accident Association, and at the time of his death he was a member of the Committee on Safety and Sanitation of the American Foundrymen's Association. He wrote numerous articles and pamphlets in the interest of the safety movement and also was one of the pioneer advocates of the sane Fourth of July. As chairman of a Committee of Ohio Foundrymen, Mr. West assisted in framing rules and regulations for the promotion of safety and sanitation in the foundries of that state, and largely to his efforts the Ohio legislature made a large appropriation to further safety work throughout that state. In view of his interest in accident prevention, his death was tragic. Struck by an automobile while crossing a street near his home, he received injuries which proved fatal the following day.

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THOMAS DYSON WEST

President, American Foundrymen's Association, 1905-1906

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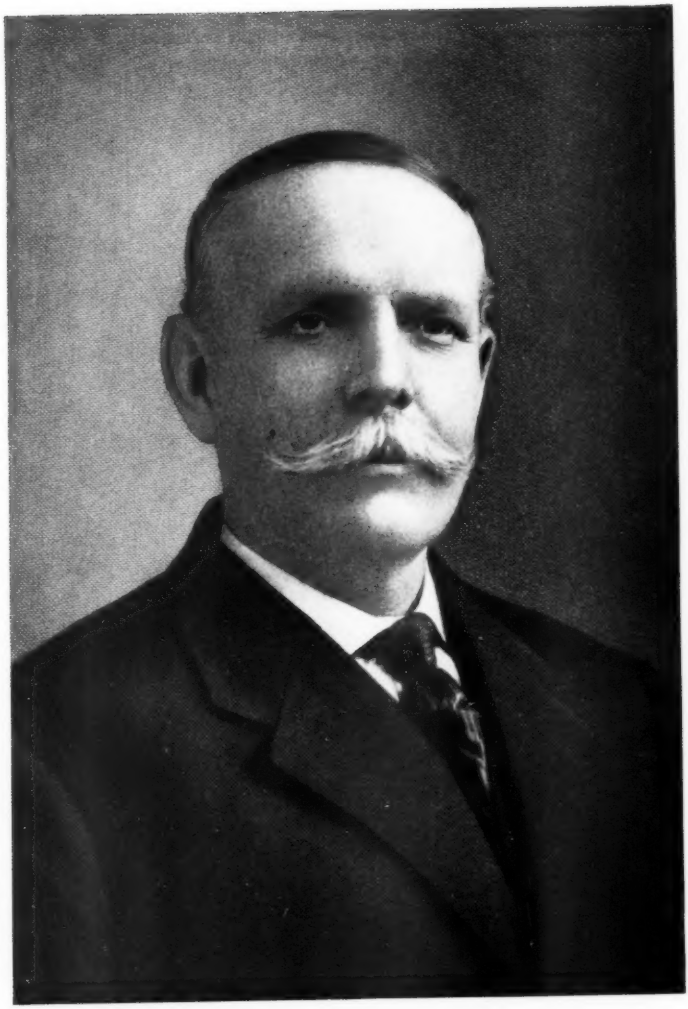

Mr. West born Aug. 31, 1851, in Manchester, Eng., but while still an infant his parents came to this country and he spent his childhood in Portland, Me. At the age of 12 he obtained employment in the foundry of the Portland Locomotive Co., and served his apprenticeship in that city, Bangor, Me. and New York. In 1871 he went to Cleveland, and after adding to his meager education by attending school for three months, he secured a position in the iron foundry of the Globe Iron Works. Subsequently he was appointed foreman of the Vulcan Iron Works Foundry, Cleveland, where he was styled "the boy foreman". His ability as a foundryman and shop executive soon became generally recognized throughout the trade in Ohio and he was offered and accepted the position of superintendent of the foundry operated by William Tod & Co., at Youngstown, O. He later returned to Cleveland to take charge of the foundry of William Fitzsimmons & Sons and in the order named, managed the foundries of the Variety Iron Works and the Cuyahoga plant of the Cleveland Ship Building Co.

Organization of Thomas D. West Foundry Co.

In 1887, Mr. West organized the Thomas D. West Foundry Co., with Samuel Lansdowne and Charles Neracher as associates. About a year and a half later, George H. Boyd invested money in the company, enabling it to make additions to its plant. Mr. Boyd became president and treasurer. In 1890, Mr. West went to the Alice furnace at Sharpsville, Pa., to test the practicability of making ingot molds by direct metal. This experiment, undertaken for the first time in this country, was successful and was soon generally adopted by ingot mold manufacturers. While Mr. West was in Sharpsville, the Cleveland plant was burned, and in 1891, the business was moved to Sharpsville, where the making of ingot mold castings by the use of direct metal was continued. In 1909, the company was taken over by the Valley Mold & Iron Co. In 1906, Mr. West organized the West Steel Casting Co., at Cleveland, which made its first castings the following year. Mr. West's' son, Ralph H., has been president of this company since its organization, while the father served as chairman of the board of directors and managing director.

From the time he entered the foundry as a boy, Mr. West was a close student of its operations and the issue of the *American Machinist* of Jan. 1, 1881, contained the first article which he wrote for publication. In 1882, his first book, entitled "American Foundry Practice", was published by John Wiley & Sons. This book is now in its twelfth edition. In 1884,

Resolution on the Death of Thomas D. West

ADOPTED BY THE AMERICAN FOUNDRYMEN'S ASSOCIATION, AT ITS ANNUAL MEETING AT ATLANTIC CITY, N. J., SEPT. 28 TO OCT. 1, 1915

RESOLVED, That in the death of Thomas D. West, the American Foundrymen's Association has lost one of its most illustrious members and the foundry industry a great pioneer in the modern foundry advance.

An investigator, author, philanthropist, a leader of men, a faithful friend and teacher of foundrymen the world over, his place will be hard to fill.

No man was more zealous in delving into the mysteries of the art of founding. No man more unselfish in dedicating his work for the benefit of his fellow men. His courage and indomitable will in introducing knowledge and betterment into shop and community stamped him a man of broad attainment who might well be patterned after by future generations of foundrymen.

His works will live after him.

RICHARD MOLDENKE, *Chairman,*
THOMAS DEVLIN,
PAUL KREUTZPOINTNER,
Special Committee on Resolutions.

Mr. West completed his second work, entitled the "Moulder's Text Book", now in its tenth edition. Upon his removal to Sharpsville, Mr. West took up the study of the metallurgy of cast iron. At that time, founders the world over were buying, mixing and testing iron by fracture and Mr. West was one of the pioneers to advocate the purchase and mixing of iron by chemical analysis. In 1897, Mr. West published his third book,

"Metallurgy of Cast Iron", which has had a very large sale and is now in its fourteenth edition. His latest book, "The Efficient Man", was published in 1914. He was also the author of six instruction booklets, which he wrote for the International Correspondence School of Scranton, Pa.

Mr. West was an honorary member of the American Foundrymen's Association, Philadelphia Foundrymen's Asso-

An Appreciation of Thos. D. West

By Dr. Richard Moldenke

Mr. West was called from his activities, much too soon for the good of the foundry industry, but not too late to have experienced within his lifetime the rare satisfaction of achieving success, and seeing his work for foundry betterment accepted as authoritative the world over. He was recognized as a foremost authority on practical foundry operation. He was a genial, optimistic, whole-hearted man, full of sympathy toward his fellows, but none the less ready to apply the surgeon's' knife to the roots of inefficiency, self-indulgence, incapacity and carelessness he saw springing up to engulf mankind. The modern movements for safety and efficiency owe much of their early progress to him—to his facile pen and constant and unremitting effort. To record all of his services to the foundry world would fill many pages. Old and young foundrymen the world over will mourn his loss. His amiable qualities will live long in their memories, and his constant striving after the truth will help to spur on others to do likewise. Truly of him it can be said that "his works live after him."

ciation and the Pittsburgh Foundrymen's Association; he also was a member of the American Society of Mechanical Engineers, American Society for Testing Materials, American Association for the Advancement of Science and the Civil Engineers' Club of Cleveland.

Mr. West is survived by his widow and by three children, Dr. Thomas J. West, of Honolulu; Ralph H. West and Mrs. William E. Ward, of Cleveland.

The Modern Foundry Advance

By Dr. Richard Moldenke, Watchung, N. J.

One of the most fascinating studies that can be imagined is that of the history of iron founding. In digging up the old records of iron-making, and separating out that which is of interest to the foundryman one can trace the development of the industry and its spread from one country to another, notwithstanding the secrecy that surrounded individual effort in days gone by. The links in the chain of events were forged very slowly and in no comparison whatever with the rush of modern development.

Cast iron may be considered a rather accidental and highly undesirable adjunct to the iron-making processes of ancient times. Well-known in Japan and Greece at the beginning of the Christian era, the first recorded example of pig iron making harks back to about 1300 A. D., in Westphalia, Germany. Sussex, Eng., followed this lead about 50 years later, when the primitive furnaces were used to produce *blooms* of wrought iron direct from the ore with charcoal fuel, occasionally yielding molten iron. This was of white fracture owing to the high manganese content and the workmen producing it accidentally were heavily fined therefor. When, however, it was found that such metal could be cast into cannon balls there came the dawn of a new industry. Furnaces were enlarged and artificial blast introduced. They were run alternately for blooms and direct castings, cannon and shot being the only objects cast in those days. The oldest German gun dates from 1414, and of England, about 1516. Charcoal was the fuel used exclusively until Dud Dudley substituted coke of a kind, in 1619, in his own

iron-making establishment. The real introduction of coke commercially, however, falls to the credit of Abraham Darby, in 1730.

An early book on iron-making, preserved in the library of the famous Berlin Armory, dated 1454, describes the furnace then used as having a chimney over the hearth for better charging of ore and charcoal in layers, this chimney having been capped by a *Kuppel* or cupola, from which our modern designation is derived.

As the art of molding was well known at the time iron came into use, having advanced materially since the Bronze Age—the lost wax and loam molding processes having been thoroughly understood—it can be said that all the iron foundry can show up to the year 1500 is the use of *off* heats cast into guns of uncertain quality and molded probably as good as could be done today. With the year 1500 came the advent of the cast iron stove, the making of which spread over Europe quickly, and with it came an extension of iron-making to practically all countries having iron ore within their confines.

Early Stove Plate Work

The casting of the comparatively heavy plates making up a stove meant open-sand work, and if this did not originate green-sand molding, it at least opened up a field for this class of skilled labor. The use of flasks came after this, the more modern development being credited to the aforesaid Abraham Darby, in 1709. Necessarily the development of the stove, with its biblical ornamentation, and the growing tonnage of the casting industry meant greater attention to patternmaking. By the beginning of the eighteenth century the putting together of patterns from collections of ornamental dies of wood mounted upon boards and pressed into the sand had ceased, and patterns were made of one piece and highly finished. The beginning of the nineteenth century saw them of metal and nicely polished.

So that when the cupola came into existence in the early days of the eighteenth century, when a Frenchman conceived the idea of remelting pig iron in a separate shaft furnace instead of the regular blast furnace—and thus brought the foundry into being as a distinct industry—there existed probably everything essentially necessary that we have in our foundries today,

less efficient and on a much smaller scale, it is true, but able to turn out first rate work. The fact that castings made 100 years ago are successfully used today would prove this, and the reason for the remarkable modern foundry advance is to be looked for not so much in the castings shipped from a foundry plant, as in the thousand and one details of equipment and management from raw material production to the last of the finishing processes.

Aid of Science to Practice

Practice has called in science to aid it, and between the two a world of accomplishment has resulted. So long as cannon did not burst during the first dozen discharges, and stoves did not crack when the first fire was lit, no one worried about the metal in them. The irregularities of the blast furnace may have bothered the furnaceman, but his customer did not know this. Dud Dudley distinguished gray, mottled and white iron, and undoubtedly suffered from this division in making his wrought iron therefrom afterwards, but if the kettle made for the housewife did not break she was satisfied. With the advent of the steam engine, however, and captains of industry who had to be shown why castings would break under this altogether different usage, as their own pockets, and not that of nations were concerned, things began to change and more reliable results were necessary. Hence, the remelting of pig iron which had been selected by its fracture as being of as nearly uniform a structure and suitability as possible. To the eventual unreliability of this method of judging iron, after the requirements of the machine shop, testing room and service demands became more stringent, and the blast furnaces had been crowded in capacity to the detriment of quality, do we owe the modern foundry advance forced upon the industry and ably developed by its pioneers in this departure.

Rarely has an industry been revolutionized in its methods and accomplishment as quickly as that of the foundry. Most of us living today remember the time when the foundry foreman practically ran the business. He made prices, bought pig and scrap, and oftentimes had to put up the more difficult molds. On the cupola platform the melter charged pig, scrap and anthracite indiscriminately though fairly well proportioned, as

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his results ordinarily came out well. It is but 32 years ago that the writer, while studying at one of the world-famous scienific schools, remembers the foundry discussed in a few brief lectures, and in no connection whatever with the chemistry of iron. Contrasted with today, what a mighty change has taken place, when even our foundry foremen calculate mixtures and argue over the second decimal place.

Advances Summarized

A summary of the modern foundry advances, as enumerated by the author in a book now in preparation, follows:

1.—The change in the valuation of pig iron from the unreliable method of judging it by fracture to the definite one of its actual elemental content.

2.—The introduction of machinery and processes to promote efficiency in operation and reduce shop costs; in specialty foundries, enormously so. The molding machine is the most prominent example of this advance.

3.—The study and rational use of foundry raw materials, such as molding sands, fuels, smaller supplies, etc.

4.—The machine-casting of pig iron.

5.—The standardization of methods of sampling and analysis of pig and cast iron. The preparation of standard drillings of cast iron for laboratory checking was first worked out by the foundry interests and is now a governmental activity.

6.—The classification of finished castings by their analysis ranges, so that the best composition can be selected as suited to the requirements of the case, and ready duplication is possible.

7.—The operation of gray iron and malleable foundries with scientific laboratory aid.

8.—The introduction of standard specifications for pig iron, cast iron and coke.

9.—The broadening of shop practice to include oil and gas fuels, improvement of product by steel and alloy additions, the electric furnace, etc.

10.—The study of the chemical and physical characteristics of cast iron, the results of which have taken it from the list of unreliable materials.

11.—Development along lines of foundry betterment, such as lighting, heating, sanitation, safety, efficiency and foundry education.

Two developments stand out pre-eminently in this array of achievement of the last 25 years and epitomize the two general directions of foundry evolution. These are the introduction of foundry metallurgy and of the molding machine. Opposition to both advances was most determined and hence, to live and spread, solid merit was essential. Of the thousands of foundrymen operating today the world-over, the progressives all mix their metal by analysis and use molding machines, and it will be but a question of time and inheritance by another generation until the others do likewise.

Men to Whom Credit is Due

The man to whom more credit is due than any other for modern foundry advance was the late Thos. D. West. While contemporary investigators were at work in other countries also, nevertheless, every development recorded in this country was closely studied by them for further improvement and adaptation. To Prof. Thomas Turner, of England, and the late Prof. A. Ledebur, of Germany, must be credited a large share in the general advancement of foundry practice.

In any new development those who are on the firing line will usually work along their particular bent, and so we have one man studying cast iron from the standpoint of the mechanical engineer, another as a physicist, or as a metallurgist, and still others as production specialists. The moment the demand for a change or improvement was made plain, inventive genius stepped in and devised the necessary machinery to cope with the situation. The proceedings of the foundrymen's associations, the technical press, governmental activity and inspection tours of foundrymen, all served to acquaint the foundry world with the progress made, and gradually the secrecy existing gave way to a wholesome interchange of experience with consequent increase of efficiency in individual plants, a better understanding between foundrymen, and the raising of the industry to a higher plane ethically and industrially.

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In the early struggle for light much effort was wasted. Stars would appear on the horizon of foundry progress only to fall by the wayside. As usual, little knowledge proved a dangerous thing and attempts were constantly and disastrously made to cure the symptoms of defective practice instead of eradicating the disease. The writer often was called into consultation to overcome difficulties where the local specifications called for a given graphite content in pig iron, completely ignoring the silicon and sulphur, and again, woefully small test bars were relied upon in judging the daily run of work. From it all, however, came some good, for a knowledge of what not to do is just as essential as being able to hew to the line.

Pioneers in Foundry Advancement

Following the line of improvement we note many well-known names. No man was better in laying out experimental detail in any investigation than West. No man was more patient in piling up test records than Keep. No one delved into the mysteries of cast iron with more interesting results than Outerbridge. Scott, Field, Saunders, Davies and many others can be cited as having advanced foundry science. In England, Longmuir, Hatfield, Stead and Buchanan represent solid achievement, while Juengst, Heyn, Wuest, Leyde and Osann may be quoted for Germany. France, Belgium, Italy, Austria, Sweden must not be forgotten either, while younger men are now engaged in following the ramifications of the roads discovered by the older heads. Many promising men, unfortunately, have found the lure of the financial side of the industry more attractive and have ceased to count in the foundry advance.

Our local foundrymen's associations were the original battlefields on which foundry ignorance and superstition were assailed. Papers were read and discussed and opinions influenced. The proceedings of the old Western Foundrymen's Association, of Chicago, were replete with information. The Philadelphia, New England and Pittsburgh Foundrymen's Associations helped to direct foundry procedure into proper channels, while the American Foundrymen's Association served as the clearing house for them all. Other bodies such as the Ameri-

can Society of Mechanical Engineers, the American Institute of Mining Engineers, the American Society for Testing Materials, etc., took up the good work and facilitated interchange of thought between the foundrymen and other professions, while in Europe the British and the German Foundrymen's Associations did similar good work in connection with the Iron and Steel Institute and the Verein deutscher Eisenhuettenleute. Today, therefore, there are few foundrymen without the knowledge of what to do, even though they may not care to or circumstances prevent them from taking advantage of such knowledge.

Mechanical Development

Coincident with this endeavor of definitely locating the underlying general principles of iron founding, there was developed the mechanical side of the foundry. The late Harris Tabor, E. H. Mumford and Henry E. Pridmore were pioneers in the molding machine line. The mechanical side of molding, with its acme in the jarring machine, can best be studied from the advertisements in the technical press. The inventors and every molding machine itself, deserve the hearty commendation of foundrymen, for in spite of the defects and weaknesses of some of these machines, there is a place for all of them somewhere in the foundry and the discriminating foundryman profits by their introduction into his establishment.

As all methods of procedure, to be successful, must be based upon a sound foundation, the struggle to make a uniform and high grade line of castings depended primarily upon the purchase of pig iron by actual content and not by fracture appearance. The principle of giving the customer exactly what he demanded and charging him for the additional chances and difficulties in production did not seem to obtain at the time, and hence the furnaces fought for a long time against what has since proved a blessing to their sales departments. Even to this time periodical attempts are made to formulate numbered grades with wide composition limits, when the real solution is to meet the foundryman's specification with agreed standard allowable variations dictated by safe furnace practice. Eventually the furnace had to yield to the march of progress,

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and this in turn enabled the foundryman to work to closer requirements and consequently increased the reliability of his product.

The specification of pig iron by analysis has now advanced to the international stage, but England alone, of the great iron-producing countries, is not quite ready to agree inasmuch as the warrant system in use there requires modifications to meet the new condition. That time, however, will come also, and the foundry world will have moved one step ahead.

The question of selling by analysis undoubtedly has received material aid by the invention of Uehling, whose pig iron casting machine now is found in most of the advanced furnace plants. He has the thanks of both furnace and foundrymen in this regard, for vexing questions have been thus solved for labor and cupola practice. Machine-cast iron can be judged by its fracture even less than sand cast pig iron and foundrymen must necessarily have the analysis of every shipment.

Sampling and Methods of Analysis

With the change of grading pig iron there became interjected the question of effective sampling and methods of analysis. This caused West to devise his system of standardized borings of cast iron for laboratory interchange, brought out under the auspices of the American Foundrymen's Association and since taken over by the U. S. Bureau of Standards. This association next instituted an investigation into standard methods of analysis of cast iron and coke, which question has also been happily solved. Long before this the problem of the standard test bar was taken up and settled effectually for America and is being considered for international agreement. It is hoped that this desirable end may soon be consummated.

Tables giving standard compositions for the different lines of castings have been prepared by Porter, so that today the foundryman need no longer make expensive experiments when new lines of work come his way. Establishments of sufficient tonnage have their own laboratories to give first aid in foundry

procedure, and the smaller foundries call upon the commercial laboratories as required. New furnace construction, other fuels, new methods of melting, etc., have no terrors for the well-informed foundryman, as he now knows the underlying principles of his art. The reduction of the total carbon in castings by the addition of steel scrap, with proper melting practice, has been extremely beneficial to cast iron since it has given the industry higher grade castings and has saved much work that would have been lost by other methods and to other materials.

One of the most important developments in foundry metallurgy has been the study of cupola melting carried out under the auspices of the United States Bureau of Mines, and today one need not have the slightest fear of bad results with that simplest and cheapest of melting devices—the cupola —if its principles are thoroughly understood. Even with the air furnace much of the uncertainty of results has been overcome with a knowledge of proper fuel combustion conditions and the necessity of keeping the furnace up to the pink of perfection continually, so that very short heats may be taken off, resulting in first-class iron.

Machinery has taken the place of hand labor from the very introduction of the raw material into the foundry. Grab buckets are used to unload and distribute sand and lifting magnets for handling pig iron and scrap. Mechanical charging machinery, of more or less doubtful metallurgical value, is now handling the materials going into the cupola, while conveying systems distribute sand, cores, molds and even take away castings just shaken-out, as well as refuse from the cupola dump, etc. Everywhere one witnesses the replacement of brawn by machine operation, effecting a large increase in output with a corresponding cost reduction and the saving of human effort and life itself.

The making of cores rationally, with the sand and binder questions involved, has been carefully investigated by Lane and thus one of the eye-sores of the ordinary foundry can be made to give way to a cheerful, well-lighted and ventilated workroom. In close connection with this study is the disposal of foundry

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waste material, a problem which is vexatious to city foundries. The washing of the burnt sand and recovery of a large percentage of this for core purposes is still in its infancy, but is bound to extend in time.

The study of molding sands has opened up a great field for foundry improvement both in surface appearance of the castings and in the reduction of the floor discount. The establishment of a standard range of strength of bond in the molding sand heaps of foundries, and constant checking up to see that the lower limit is not reached, will do much toward keeping the output satisfactory. The information now available allows this to be done, and where introduced has saved much money otherwise lost in defective work made until the trouble has been located.

Introduction of the Molding Machine

The introduction of the molding machine—from the old hand-squeezer to the modern types of jarring machines—has radically changed many operations. Mechanical sand tempering at night on the floor, or sand handling arrangements which collect the freshly shaken-out material in a lower story, add the necessary water and new sand, thoroughly mix and temper, reconvey to the floor above to the proper machine chutes to be used over again, are to be found in many shops at the present time. Perhaps the only weak point as yet in the application of power to aid the foundry operatives is in the handling of the mold after it is made on the machine. This is a back-breaking operation and it takes a robust man to carry away the hundreds of molds daily from the machine to the floor parking in the case of small molds in quantity casting. For the large classes of work modern crane facilities leave nothing to be desired.

With the introduction of more exact methods of working there has naturally come the need of more exact cost-keeping. While the foundry world is still very much behind in this respect, the individual operator no longer evolves the cost of a casting out of his inner consciousness, but actually knows the items making it up, apart possibly, from the overhead.

The day is coming when accurate costs will be more generally used in estimating selling prices.

Modern foundry advancement has relegated to the rear the rule-of-thumb man and a new class is in control of the industry. These men are not satisfied with former conditions and methods of operation and hence we see everywhere the introduction of betterment work. The molder sleeping off a night's debauch on the sand heap has not been witnessed in the foundry for many a day, nor does the bucket brigade parade between foundry and saloon during working hours any longer. Sanitary installations enable the molder to feel like a man among men even in the smaller establishments, and the study given the human side of the industry has increased the shop efficiency wonderfully.

There is still much to do. Contrasted with the foundries as we knew them before the advent of modern ideas there is as much difference as there is between night and day. The pioneers of foundry progress, one by one, are paying their debt to nature, and a new generation is taking up the never-ending task. May the efforts of this new generation be crowned with as much success as that scored by the pioneers and which will redound to the lasting benefit of humanity.

Discussion

THE CHAIRMAN, MR. R. A. BULL:—I am sure we all enjoyed this interesting abstract of the Doctor's paper. By natural circumstances he has been more familiar, perhaps, than a great many of us, with the advances that have taken place, and a resume of this sort is extremely interesting. We will be glad to have some discussion on the Doctor's paper.

MR. B. D. FULLER:—There is one point that the Doctor touched on but lightly, which is an important one. That is, the endeavor which many of us make to get perfection in getting different mixtures out of one cupola. It is a difficult thing

to do, but they are hitting the nail on the head in Europe, although it does seem an odd way of doing things. In this country the idea of installing a lot of little cupolas around in the shops instead of one big one, looks, on the surface, as if it were not just the thing, but very often we would be glad if we had had a lot of cupolas around.

DR. RICHARD MOLDENKE:—It is really one of the important things, because if you have studied the cupola process carefully, which is, after all, the nerve of your business, so that you may get the iron out right, and know the action of the air going in, and the processes of melting and pouring, you will see how much more difficult it is to operate a large cupola successfully than a small one, where the air penetration is thorough and the action goes on steadily. It is sometimes wonderful that results in the foundry are as good as they are. Little cupolas, are in use in continental Europe, at least, the only large ones I know of being in Scotland and England. I think that 48 inches is about the largest there is on the continent of Europe, and 36 inches is the average. It is perfectly satisfactory there, because the labor is cheap. I am afraid though, as time goes on, we will have to face such a situation here some day. We will have to work closer and closer to specifications with our material all the time, and cast iron is such an unhomogeneous material that only the work of the modern foundry advance has taken it from the class of the uncertain and unsafe things, and brought it more and more into the class of things people depend on. We have got to keep on working in this direction, to make it even more dependable all the time, and this will involve changes in our practice, and the taking advantage of all the good things other people have done. I will say, though, that if you go through European foundries, they will be found to be just like ours. Our practice came from over there. We thought we had improved it when we made 10 foot diameter cupolas, but we didn't.

MR. H. C. ESTEP:—I would like to suggest that possibly this question of obtaining mixtures of a more definite and better quality might be worked out in the future by even abandoning the cupola for certain classes of work. We see a very evident tendency in that direction through the development of

the electric furnace for melting steel, and I believe also in Europe an air furnace is used to some extent for making cast iron where the quality of the metal must be controlled more accurately than it can be in the cupola; but I do not believe that in this country there is very much cast iron made in air furnaces. There is a little for certain classes of work, and may it not be that the future will see the elimination of the cupola for work which must be of a certain quality and have certain definite characteristics?

DR. RICHARD MOLDENKE:—This is a very interesting point. It is certain that for very careful and particular lines of work, the air furnace is coming more and more into use by those great concerns which can afford to have metal that costs a cent a pound more than when made in the cupola, but I question whether the cupola will ever be eliminated, because when it is run right, it gives mighty good results. The difficulty of going too far with the demands on cast iron is that the material itself won't stand it. Cast iron is not like steel, and I have often run across the fact that where one can use a factor of safety of one or two in steel construction, you must occasionally use a factor of 15 in cast iron. Ordinarily a casting is made very heavy, not simply for the strength it has got to have, but simply because you could not make it thin for structural reasons. My impression is that for very particular lines of work, we will go more into air furnace work, and eventually, I hope, into the open-hearth. You might just as well go one step further and get the open-hearth furnace if you can keep it busy all the time. I have made much first class work with the open-hearth. The electric furnace may replace even this, but so far we are not quite sure how it will develop for cast iron. We have got to be careful that in the development of the foundry we do not run off on a tangent, otherwise somebody has got to pay for it.

XUM

Inspection of Automobile Castings

By C. B. Wilson, Pontiac, Mich.

The relation between inspection and the final cost of castings is a subject which can be discussed at great length, since a properly organized and efficient inspection department is a more potent factor in reducing the scrap loss in a foundry than any other single unit of the foundry organization.

With the exception of the foundry, the trend, for the past ten years in manufacturing industries, has been toward the most complete development of their inspection departments. I assume that foundrymen have looked upon this department as an unnecessary expense rather than as an aid in operating their plants more efficiently and successfully. Without a knowledge of what is demanded of the machine shop product, the foundry heads have always maintained that their output was not being treated fairly by the machinists. Because the foundry, for so long a period, has been making castings without a standard of quality, the machine shop, whose product depends mainly upon the foundry, has been compelled to establish its own standard for accepting or rejecting castings, and with regard only for its own protection it has placed such rigid specifications on castings that it has entailed a great hardship on the foundry.

This has been true of the automobile industry to a greater extent probably than any other line of work with which the foundry has ever been connected. The development of this industry has been so rapid and on so broad a scale that it has been difficult for the foundry to meet the constantly changing demands of the automobile engineers. Consequently, foundries have been compelled to sustain many losses unjustly; and being without the protection of competent inspection departments, there has been no redress, since the technical requirements of the engineers were beyond their compre-

hension and understanding. Many of these losses, however, could have been placed where they rightfully belonged, provided the foundry had had a corps of properly trained inspectors.

Expert Foundryman First Inspector

When the writer first began to manufacture automobile castings, he found it an extremely difficult problem to know when castings were right or wrong; but in an honest endeavor to establish a standard of quality and to develop an inspection department that would maintain this standard in his own factory, he first employed an expert foundryman. This experiment, however, soon proved an utter failure, since the inspector was partial to the foundry in all his reports and by nature antagonistic to the machine shop. The foundryman was replaced by a patternmaker, in the belief that his knowledge of patternmaking, his ability to read blue prints and his knowledge of foundry methods would eminently fit him for the position which the writer was endeavoring to establish. The patternmaker also proved a failure, since in addition to having the same faults as the expert molder, he constantly tried to protect the pattern department's product in use in the foundry. Before making the third attempt, the inspection department was removed from the direct supervision of the foundry and a thoroughly practical machinist was placed in charge. In filling the position, an effort was made to get a man who was broad enough to fully protect the machine shop and, at the same time, make due allowances for the slight variations which occur in foundry practice. His progress at first was slow, as he was greatly handicapped by the antagonistic attitude of the foundry organization, since the molders objected strenuously to accepting the views of a machinist. It was doubly difficult for him when it became necessary to make corrections in the methods of molding. However, with the knowledge he had of the manner in which the castings were to be machined and of the parts that had to be absolutely accurate, his suggestions regarding changed and improved foundry methods soon became invaluable to the molder in reducing his scrap. The machinist, having had a more thorough training

in gas engine practice than the foundryman, could prevent the molders from making changes in either gas or water passages, altering port cores, or, in fact, in making changes in any part of the casting which would be contrary to good engine practice. Also, having had experience in the use of jigs and tools in the machine shop, it was simple for him to apply this knowledge to coremaking and molding and to insure uniform castings, wooden gages were soon replaced with steel and iron fixtures.

The non-interchangeability of cores and core assemblies was a source of perplexity to the man trained in machine shop practice, and in endeavoring to locate the cause of this lack of uniformity so as to eliminate fitting and filing in the foundry, it was soon determined that patterns and core boxes would have to be repaired to insure the perfect fitting of loose pieces and removable parts. Even after the equipment was put in proper condition, it was almost impossible to convince the molder that it was unnecessary to file cores as formerly, since the force of habit and past practice governs the molding industry to such an extent that it is often difficult to introduce new ideas.

Inspection Should be Positive and Accurate

The means of inspection employed should be positive and accurate. If the casting is intricate or complicated, or has a number of machined surfaces, standard gages can readily be made and the casting placed in the same relative position in which it is to be held while being machined, and the finished surfaces and cored openings can be checked quickly and accurately. Some time ago I was making a four-barrel, *en-bloc* cylinder casting, with the crank case integral, on which it was necessary to check 20 or 25 points before it was shipped. A fixture was designed in which the casting was placed and every point to be checked was inspected at one handling. A duplicate fixture was later made by the customer and his inspection department used exactly the same method as I did when passing on the castings. In a great many cases a check of this kind may show an error in the casting which could be laid out and favored slightly without any additional expense

in the machining operation, whereas, if this is not taken care of in the foundry, the machine shop will handle the casting in the regular way and reject it as an imperfect casting.

Hydraulic Test of Cylinders

Automobile cylinder castings must be tested hydraulically before shipment from the foundry to determine porosity which may exist in the water jackets. This is done most economically and successfully where a constant pressure is maintained on the casting for a time long enough to give the water an opportunity to sweat through any pores which may exist in the casting. However, this cannot be detected as positively by the use of a hand pump, where the pressure is raised gradually and maintained for a short interval. It also is a decided advantage to the foundry to maintain a high pressure on the water jackets, thus forcing the water into the pores of the casting, which will rust any porosity which may exist. A great many times castings are returned to the foundry because the jackets leak. However, when again tested at the foundry the trouble is not apparent as the leak had been closed by rusting, and this results in an argument which, in a majority of cases, could have been avoided if the casting had been properly tested before shipment.

To maintain a uniform foundry product is difficult, owing to the fact that the human element enters into the production of the casting to such an extent. I have had jobs that have not given any trouble for months, when suddenly a greatly increased scrap loss would occur without apparent reason. Without an inspection department this trouble would probably not be discovered until the customer began to machine the castings, and probably by that time many thousands of imperfect castings would have been made, shipped, or in process of manufacture. A coremaker may have omitted a core wire, or a loose piece may have been lost from a corebox or pattern. A small core may have been omitted by the molder, or a thousand and one other things may have gone wrong without

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having made any apparent change in the appearance of the casting; unless a thorough inspection is made of every piece before it is shipped from the foundry, serious losses are bound to result.

Large Stocks of Rough Castings

Today, when single automobile companies are producing from 100 to 1,000 automobiles per day, it is absolutely necessary for them to carry a large supply of rough castings in stock. This becomes an extreme hazard to the foundry unless every casting has passed through a competent inspection department. In fact, I know of automobile manufacturers who keep two and three sets of cylinder patterns in stock to guard against any emergency which may arise. This is necessary unless a foundry has an inspection department to locate these troubles before castings are shipped and is able to remedy them before serious loss is incurred as a result of the customer carrying a stock of several thousand defective castings.

Only too frequently the machine shop returns castings to the foundry which have been spoiled through its own neglect, and unless protected with a competent inspection department, the foundry eventually absorbs nearly all the machine shop loss. But when such rejected castings are again inspected by the foundry and the machine shop is compelled to tag each casting with the reason for its return, rejected castings are reduced 75 per cent. There also follows an increased measure of respect between the machine shop and the foundry and business relations are decidedly more satisfactory.

The work of the inspection department does not end with checking the mechanical troubles of the foundry and core room, but it is necessary that its reports cover the machinability of the iron. The inspection department should be provided with a lathe and drill press to turn and drill castings to determine whether the iron is satisfactory. It is true, that the chemist has his analysis and test bars, but he must be checked in this as a great many things can happen between the charging door and the shipping room which will upset all his calculations. Then, too, it is always a good plan for the inspection

department to take a cut off certain castings to determine whether there are any draws, shrinks or porosity which should have the attention of the metallurgist or the foundry organization.

Stopping Losses Promptly

Foremen and superintendents, in their executive capacities, can recommend methods for reducing scrap when such losses are directed to their attention, but without an inspection department these losses may occur for a considerable time before they become cognizant of them; and even then, if the loss is not stopped at once, another period of loss is experienced until it again has the executive's attention. An inspection department detects loss, and after a careful analysis, determines the cause and sees to it that the loss is stopped at once or that some good reason is given.

Most foundries maintain a salvage department which should be under the supervision of the inspection department. Any castings sent to the salvage department should be reported as scrap to the foundry. If this is not done, no effort may be made to eliminate the troubles.

The rapidity with which the inspection department is able to make reports of defects, with their causes, to the foundry organization, is a factor of the utmost importance. I have found it good practice to run the cleaning room during the night and have the first rough inspection report ready by 8 or 9 o'clock the next morning to enable the foundry to check errors in core setting and bad molding which had caused defective castings on the previous day. A report of only the number of castings lost or scrapped is not sufficient, but a reason should be given for the loss of each casting. Many times it is hard to determine the reasons for a defect, but by a careful inquiry and analysis it is always possible. Many times the superintendent and foreman are unable to give a reason, but when the inspector goes to the workman he finds that he has been ordered to do the work in a certain way and the molder will not criticize the judgment of his superiors unless shown that his individual record is being damaged by an excessive scrap loss. When this personal interest is instilled

in the molder and coremaker it is comparatively easy to get them to co-operate in reporting when cores are wrong, or core boxes and patterns are out of shape; in this way they really inspect their own equipment and work and thereby contribute to the reduction of scrap. It is this latter objective towards which the inspection department should constantly work, not alone to increase its own efficiency and skill in checking and inspecting castings, but to instill in the molder and coremaker the necessity for accurate and careful workmanship and the spirit of co-operation and willingness to receive instruction relative to ways and means of reducing their scrap. With this spirit instilled in the workman, half the battle for the reduction of scrap is won.

Reports Form a Permanent Record

I have always found it good practice to make a permanent record of all the reports from the inspection department, compelling it to record the reason for scrapping each casting, sending one copy daily, and as early as possible, to the foundry and filing one copy for future reference. A recapitulation and an analysis of these reports every week or 10 days, giving the average loss during that period, gives a more comprehensive knowledge of the operation of the foundry than that gained from the analysis of a single day's report. Unfortunately, I have found that it is always the tendency of the foundry organization to say: "Yesterday's troubles will be cured today." However, today's troubles are something else, but with a complete story of the past week's scrap one has an excellent argument demanding a more determined effort from the foundry organization to overcome these same losses in the future. Also, a record of this kind is helpful in starting new orders for work which previously has been made in the foundry, since the elimination of the liability of repeating bad practices will insure a decreased scrap loss.

Cost of Inspection Department

The cost of maintaining an inspection department is quite an item unless results accruing from its operation reduce costs, either in manufacturing or in the reduction of the number of

castings returned. The success or failure of a foundry is found in its scrap pile and if the inspection department is a factor in reducing the scrap of a plant, it has paid its own cost many times. For example, if the direct and indirect costs of a foundry are $400 per day and the average scrap loss is 20 per cent, the cost of good castings is increased $100. An inspection department of five men would easily take care of a foundry of this size at a cost of about $15 per day. If by this means the scrap loss is cut to 10 per cent, there is at once a saving of $55 less $15, the cost of inspection, which would net $40. Not only is the cost of good castings reduced in the ratio of reduced scrap, but all indirect costs are at the same time cut to a minimum, as laborers throughout the whole plant are handling material which pass out of the shipping room door and are returning a revenue; while with a high scrap loss, fully 15 per cent of the labor in the foundry is consumed in handling scrap castings from the molding room to the cleaning room and to the charging floor. At the same time, the foundry is able to increase its production without the addition of equipment such as molding machines, flasks, etc., and is then working on an efficient basis, reducing costs, cutting out superfluous indirect expenses and increasing the output.

Elimination of Competition

The foundry that endeavors to inspect its own castings and prevents its organization from trying to impose defective material upon its customers, with the hope that they may overlook it or in some way be forced to use it, will eliminate nearly all competition. When a machine shop forms a connection with a foundry which gives service and quality, keeping all casting troubles in the foundry, it is a difficult problem for a competing foundry to get an opportunity to quote prices. Also, the shop with a reputation for quality will get from 10 to 15 per cent more for its product than the foundry not so protected. It also instills in the customer a feeling that he is being treated fairly and makes him less critical, while the rejections are less subject to the erratic temper of his machine shop foreman. Also, the machine shop organization will be more inclined to work with the foundry management when castings show some

slight defects, especially when they are notified in advance that certain castings are not up to standard, but that corrections have been made and that with a slight adjustment in their fixtures, they will be able to use them. With this feeling of fair play and co-operation between machine shop and foundry, rejections can be reduced to the minimum.

It always has been my contention, that the inspection department, once properly organized in a foundry, is of the utmost importance and will determine, to a large extent, the failure or success of the entire business. The proper use of reports and information gleaned from the inspection department will reduce the scrap in the foundry, which in turn reduces overhead expense, increases output, standardizes quality, makes satisfied customers, eliminates competition and insures the permanent success of the business.

Discussion

THE CHAIRMAN, MR. B. D. FULLER:—Mr. Wilson's handling of this question is quite interesting. I fully agree with him as to the value of inspection in connection with works handling any great amount of business. The paper is now open for discussion.

MR. A. B. ROOT, JR.:—I would like to ask the speaker, taking a man out of the machine shop as he advocates, how long it takes him to become sufficiently acquainted with the conditions in his plant to enable him to accurately judge whether a casting is suitable to be passed?

MR. C. B. WILSON:—In answering the question I would say that it was fully six months before the machinist got to the point where he was handling the inspection in a satisfactory manner, and in handling the inspection on automobile castings he must, in the beginning, have a kowledge of what the machine shop is doing, as most of the fixtures used in a machine shop today are solid, with no adjustment, so that a variation of 1/16-inch in the width of the casting will throw

that variation all one way. When I state that if he knows in advance that variation exists and will write to the machine shop that is going to use the casting, they will divide the variation nine times out of ten and throw one thirty-second of it on either side; that was one of the main reasons, in handling automobile castings, why we never could educate a molder or patternmaker to realize that 1/32 or 1/16-inch meant anything.

MR. A. B. ROOT, JR.:—That is all right from that end of it, but suppose that it acts the other way and this machinist must recommend that a change be made in the molding of that casting; what is his position then?

MR. WILSON:—The machinist's authority does not extend to the point that he could dictate to his superintendent. His reports in themselves show the scrap lost in such a manner that your supervision really takes care of the handling of the molding end of it. When, at the end of six months, he got to a point where he could define, without getting into any serious controversy with the foundry, what was a blow-hole or a sand-hole, etc., or where it was a loose boss or defective core print, then the balance of his duties was turned over to foundry supervision.

MR. G. C. WEBSTER:—In connection with the paper just read, I believe I could elaborate upon it somewhat with a few words about a concern with which I am well acquainted—in fact with which I am connected—and that is the plan we follow in our inspection department for recording errors and complaints. When a mistake has been made in any line of work, or where a complaint comes in upon any order, the superintendent thoroughly investigates it, and the facts in the case are carefully recorded. Then a bulletin is issued from the superintendent's office covering the trouble, or the defects—in case it is a mistake upon an order—the data are all set forth in the bulletin, also the remedy and a plan for preventing the mistake from occurring again. A copy of this bulletin goes to everyone directly interested in the particular mistake, and if it covers an order, then the number of the bulletin is noted upon the copy of order on file in the inspection department, and consequently, when another order is received from the same concern, that bulletin number is automatically brought

to the attention of the foreman of that department; we always refer to the last order previous, in order that we may have the history of past troubles if there have been any. This you can see brings the foremen and the men directly interested almost automatically in touch with any trouble, even though it has occurred six months, or even a year before. We have found that this system of bulletins works out wonderfully well along many lines, because it is a perpetual record of our experiences, and while the majority of us find that our men know of the mistakes made, and the means of guarding against them, it is not always made a matter of record—and experience becomes an asset just to the extent that we have it recorded. When a new man is placed in a department, or one is advanced from one department to another, the foreman in charge of that department sees that the new man has brought to his attention any bulletins covering data and experiences with which he should be familiar, and in case a foreman is changed or advanced, then the assistant foreman, upon taking his place, is given the foreman's bulletin file, and in this way he has a fund of information. Thus, with our bulletin system we have a record of instructions, suggestions, as well as some regulations by which our men can be instructed and guided.

MR. G. J. FISCHER:—How do you remember there was a complaint on this particular casting, or who issues that order? Maybe you had an order six months ago and there was a complaint on it and there is another order coming in today for that same kind of a casting; how will you remember that there was a complaint once before on that casting?

MR. G. C. WEBSTER:—The inspection cards indicate plainly anything which may have gone wrong, and after the trouble has been thoroughly investigated, and the causes ascertained and a remedy determined, this is made a matter of record in the form of a bulletin, and the order upon which these castings were made, or whatever the order may cover, is marked "Refer to Bulletin No. —". When an order is received, our order department invariably refers to the last order received from that firm, because there are a lot of technical, as well as commercial data which have been collected from time to time, and which are always noted upon the order, and the notation

"Refer to Bulletin —" becomes part of these data. This you will see, almost automatically keeps the causes and remedies of our troubles a matter of record. We find it is very helpful when bulletins are issued which cover the instructions for any given work or plan, to place a follow-up on these bulletins; for instance, bulletin No. 47 may cover instructions to the cupola man, then upon the face of the bulletin is noted, "To be followed up every month on the 15th." These follow-up cards are all filed in a tickler file in the office, and each day the follow-up cards for that particular day come up automatically, and one of the office girls fills out a form which we have, which goes to the cupola man and he has to go on record, as to whether or not he has recently read bulletin No. 47, and whether or not it is being lived up to faithfully. He is also asked if he has any suggestions to offer which would make that particular bulletin more valuable. Our bulletins are followed up every week, every month, every two months, or six months, as the nature of each particular bulletin requires. In this way, the mistakes of the past, the methods we have worked out for overcoming them, our instructions governing anything in connection with our factory, in fact anything which we want kept before our men, is kept automatically before them.

MR. G. E. JONES:—We use a similar system, consisting of two forms, a green sheet for recommending changes and an orange sheet for corrections. During construction, if a design is found to be inconsistent with economical handling in the shop a recommendation is made on a green sheet and sent to the superintendents office. It is then discussed in conference and if approved one copy is sent to the engineering department and the other retained in the superintendent's office for follow-up purposes. If an error is found in the drawings or any of the parts entering into the construction, a notice is given to the department making such error, on an orange sheet, one copy being retained in the superintendent's office for follow-up. In this way it is impossible for the matter to be overlooked or neglected. We find this helps materially to minimize the duplicating of errors.

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Defects Common to Gray Iron Castings—Their Causes and Remedies

By Herbert M. Ramp, Cincinnati

A comprehensive discussion of the causes of defects common to gray iron castings and remedies for overcoming them would encompass the consideration of practically every foundry operation, but unfortunately the time at our disposal will permit only of a brief review of this interesting and complex problem. A discussion of the losses incurred by defective castings is one of the first things a man hears when he enters a foundry and it usually is the last thing that comes to his notice when he leaves it. Unfortunately, more attention is given to the losses incurred by defective castings than to making improvements that will eliminate practices that cause them. More consideration is given the pounds of bad castings a molder produces than to his output of good work. Also, more importance is attached to the bad castings reported than to the cost of productive labor per ton. The reason for this is not hard to find. The one is a tangible, direct loss that stares the foundryman in the face every day, while the others are intangible factors that can be corrected by the exercise of gray matter and the installation of proper equipment.

It is estimated that defects common to gray iron castings are the direct cause of the rejection, or loss, of at least 5 per cent of the iron castings produced. Some patterns may have a better record, although many, also, will show a higher percentage of loss. This estimate on the average, however, is low. If this loss were eliminated many foundries struggling for existence today could net a profit on their operations. The reduction of the defective output is a problem of great importance and should command the earnest attention of every foundryman.

Ninety per cent of all defects can be attributed to two causes, namely, incompetency and carelessness. However, since it is exceedingly difficult to obtain competent and careful labor, the operations involved in making castings today must be so safeguarded and simplified that a lesser degree of experience, intelligence and care is necessary to the successful operation of the casting plant than heretofore. Classifying casting losses in the order of their causes, it will be found that 50 per cent can be attributed to the sand and its treatment, 20 per cent to the cores, 10 per cent to the patterns, five per cent to equipment and five per cent to the iron.

What constitutes defects in gray iron castings is another question of great importance. The standard of excellence for the different classes of castings varies and consumers using castings of a similar nature for the same purpose, frequently will have widely varying requirements. In other words, castings that will be accepted by one company will be rejected by another and the line differentiating sound from defective castings is drawn at different points. In this respect every consumer is a law unto himself, and there really is no standard for casting quality. Each consumer fixes what he considers a standard for his own requirements which he believes is adequate to his needs.

Sand as a Cause for Defectives

No effort will be made to enumerate the many causes leading to the production of defective castings as the list will be entirely too long and, furthermore, in many instances the causes are so obvious that further comment is unnecessary. However, some practices are common to many shops which cause needless expense and these are repeated day after day in one form or another without an intelligent effort being made to correct them. The sand, and its treatment, is probably one of the most prolific causes of defects, and to it can be attributed more losses than to all other causes combined. In three cases out of four, the sand is the cause of dirty castings; it causes the mold to cut and the castings to scab and blow. If a casting blows, it generally is attributed to the cores, the

sand or its treatment, and its repetition is guarded against. However, the cause of the cut, scab or buckle is not investigated carefully, notwithstanding the fact that the losses thereby incurred are deadly to profits. It is the small defect that causes the foundryman to stop and wonder if the casting will pass the machine shop, but finally after it has been cleaned and shipped, it is returned with a caustic letter of complaint. It might be pointed out in this connection that the little foxes spoil the grapes. A casting that is defective beyond question usually points out its own remedy, but the casting which is questionably defective is the most elusive. The remedy is not sought as earnestly or intelligently as that causing the larger defect, neither are the molders instructed as carefully to prevent the causes of small defects as those which are more apparent.

The foundryman usually becomes provoked and exceedingly angry when a molder has a run-out or breaks a casting hot. He views this in the light of exceedingly poor workmanship, but he considers in an entirely different spirit a casting that is slightly scabbed or dirty. The casting that is *almost good enough* offers the most difficult problem and the cause of its defect, as a rule, cannot be determined readily.

Scabs, Cuts and Buckles

Scabs, cuts and buckles come and go. They vary with the temperament of the man who wields the rammer and the vent wire and blossom forth with the use of too much water, too much finishing, too little venting and the use of improper sand. When the foundryman discovers a scabbed casting, he usually tells the molder to be more careful, or advises him that the mold was too hard or too wet, or whatever his judgment dictates, but how often does he examine the facing and the sand? How often does he employ every possible resource to secure better sand or to make mixtures of sand for his work that are more satisfactory? How often does the foundryman show the molder how to ram the mold, to vent or finish it? How many foremen today believe that they discharge their duty by merely telling the men in their employ what is patent to any one who has walked through a foundry a few times in place of

personally instructing them how to avoid their troubles and to do their work right?

Poor or misused sand is the cause of more defective castings than any other factor. It has a decided influence on the cost of the product and may be the means of establishing a reputation for high grade or poor castings. It is the foundation upon which the entire foundry structure is built. Suitable sand means better and cheaper castings, lower losses and an easier shop to operate successfully. It is one of the great fundamentals of a happy business.

Preparation and Use of the Sand

Next in importance are the instructions issued regarding the preparation and use of the sand after its careful selection, consistent with its cost. However, cheap sand frequently is the most expensive raw material that a foundry can buy. The sand must be mixed and tempered for the particular work for which it is required and this must have the attention of the supervising force. The molder next must be instructed in its use and if defects develop in his work, he must be taught, regardless of the fact that he may have pounded sand for 40 years. It is futile to attempt to formulate fixed rules covering supervision and instruction, since every foundryman has individual ideas on this subject. However, not many realize that the cause of defective castings might be eliminated if they would start at the sand bin and see to it that the best possible sand is obtained and that the proper instructions are given regarding its use. Too frequently, also, this instruction partakes of the form of criticism, when the molder is called to the scrap pile where his defective castings are pointed out to him in no uncertain terms. In other words, in most instances, what should be well-intended instruction, is mere denunciation. Anyone can find fault, but a man must study his business if he wants to place himself in a position where he may be able to correct bad practice. The average molder does not lose a casting on purpose. He feels regretful over its failure, but the average molder does not always know the underlying cause of defects, nor how they may be overcome. He needs help, not

hell, which he usually receives. He must be taught the rudiments of the business over and over again, since the conditions of the trade are changing constantly. This is the remedy that must be applied by the supervising force before the defective losses can be reduced. If the same energy is expended in instruction as in condemnation, far more satisfactory results will be achieved.

Dirt Another Cause of Defects

Dirt ranks as the second of the prolific causes of defective castings. From a molding standpoint, the casting may be perfect, yet it is dirty in the rough, or it may display dirt spots in the finishing operations. The number of excuses attributed as the causes for dirty castings is legion, yet only two can be assigned for this defect. Either the iron does not lie quiet in the mold, or against the cores, or dirt has been permitted to enter the mold with the iron, or it was in the mold at the time when the metal was poured. Occasionally the blacking may wash; again the gates will cut, but more often the dirt can be attributed to the same cause as that of the scab or buckle, namely, improper sand, or its improper treatment. A casting will not be clean when the iron does not lie quietly in the mold. The metal may not boil or agitate sufficiently to cause a scab, yet its effect is apparent on the finished casting. If the slag which accumulates on top of the iron is permitted to enter the mold, the casting, of course, will be dirty and this is true also if the gates cut or scab, or if the gates or runners are improperly constructed, or are defective in any way. It is possible to make a perfect mold, yet if the gates are improperly made, the casting will be dirty and will prove defective. Here again the remedy is care and supervision.

An excuse generally offered for defectives is dirty iron. This is the bulwark behind which the molder hides and is the shield which he employs to cover his shortcomings. First of all, it might be well to direct attention to the fact that iron and dirt are enemies and have nothing in common. The dirt referred to is the foreign substance that occurs or forms on the

upper side of finished castings. Iron and dirt have no affinity and are of widely different specific gravities. Ninety per cent of the so-called dirt in castings is composed of silica, alumina and magnesia and none of these is mixed with iron mechanically. They will not remain in solution by any known process, but they may unite to some extent chemically, in this event changing the chemical composition of the iron. This, of course, could be readily determined. However, the natures of these elements are not similar, repelling each other, which is indicated when such substance rises to the surface of the metal in the ladle. Some of the different oxides contain iron, being formed while the iron is in a liquid state and subjected to the action of the oxygen in the air. These oxides also are classed as dirt. However, this dirt, the same as any other refuse that rises to the surface of the metal in the ladle, must be skimmed-off before pouring and does not form a part of the iron. Oxides cannot form, however, after the casting is poured.

Dirty Iron

Iron is unlike most of the non-ferrous metals, in that it will form only a comparatively few combinations with the exception of those produced in the blast furnace. It repels all but a few elements that are taken up in almost constant proportions and these only at extreme temperatures. Regardless of the composition or the character of the iron, if it is melted and poured fairly hot, it will be clean. The sulphur may be 0.05 or 0.20 per cent, the manganese may be 0.20 or 2 per cent, the phosphorus may be 0.10 or 1.25 per cent, but none of these varying contents of these elements will make iron dirty in the castings. The iron may be too hard, too soft, too open; it may shrink, crack, draw or warp, but dirt is not its inheritance, nor its progeny.

During the past 25 years, the author has had direct charge of the mixing and melting of more than 500,000 tons of iron, but he has yet to find dirty iron in the sense assigned for it by the molder. Why does a molder make nine castings good and one bad? Why does a molder make a clean record for 30 days and then lose everything he makes? If a molder can

produce 20 good castings why is he unable to make 21 or 200? These are the questions put up to the foundryman every day and he has yet to give a convincing answer. First of all, there are no standards or set regulations governing foundry work. The sand may be wet down more one day than another and this makes different the ramming, venting and finishing problem if the castings are to be good. The iron may be colder and duller one day than another, and this would necessitate the use of gates of different size, or different pouring arrangements and the cores may be swelled out of shape, which would require different methods of securing. The flasks may be worn out and finally give way and a hundred other conditions may arise which never are the same on subsequent days.

Inexplicable Foundry Problems

Little has been done in most shops to remove the many causes of defective castings, except in foundries specializing in a particular class of work. No effort has been made to catalog the ills of the foundry and no one has attempted to place the foundry business on a level with the machine shop. If this were done, many and marvelous changes would be made. The patterns, core boxes and flasks would be inspected daily, the sand would be prepared by machinery and the different grades and ingredients would be carefully measured; different rules would be laid down covering the pouring temperature of the metal, as well as the methods of gating. The foundryman would have a voice in the design of the patterns and he also would have the patterns made, not the cheapest way, but the most satisfactory way for foundry use. Every possible pattern would be mounted on a molding machine instead of placing so much dependence upon the skill of the individual operator. Either by lectures, by a school course, or through technical papers, would be imparted to the molders the knowledge gleaned by the employers as the result of the development of the business. Premiums would be paid for high grade service and efficiency.

The foregoing and many more factors would contribute as remedies for defective casting losses. Unfortunately, these

needs cost money and the trail has to be blazed; some must be pioneers in elevating foundry practice to a class where definite standards exist and where definite practice will produce definite results.

The Personal Equation

In a large measure the personal equation will have to be limited and particular jobs will have to be so safeguarded that if Tom Jones lays off a day, his substitute won't make 50 per cent scrap; that if Mike Murphy has been out the night before, he won't spoil his day's work; or, if a molder has sickness at home, he won't forget some minor detail and ruin his casting. More of the responsibility, judgment and skill must be taken away from the individual and the work must be placed upon a higher mechanical basis than it is today. Then, only, will the beginning be made for the elimination of defects in castings. An honest comparison of the defective work of the ordinary jobbing foundry with that of the shop equipped for a special line of work, proves conclusively that defectives can be reduced by placing operations on a higher mechanical plane.

Pouring Systems for Gray Iron Foundries

By H. Cole Estep, Cleveland

In the great majority of foundries, including many that run very heavy daily heats, the molders are required to pour off their own work, it not being practicable except in a few extremely large plants handling certain classes of work to subdivide the labor to the extent of employing special pouring gangs. Molding machines, however, have now become so perfected that on many classes of work it is not difficult for a man to put up more molds between 7 a. m. and 3 p. m. than he can conveniently pour-off during the remainder of the working day. In many cases, this condition makes it necessary to operate the molding equipment at less than its capacity because of inadequate facilities for handling the molten metal. In other words, the output is limited not by the capacity of the machine, but by the strength of the man who carries the metal to the mold.

This situation has led many foundrymen to give serious consideration to the installation of mechanical pouring apparatus, in order to balance up the work in the shop and obtain a maximum output from the molding machines. In the comparatively few shops where complete pouring systems have been installed, the results have been exceedingly gratifying and the investment in pouring apparatus has been rapidly repaid. In one shop in Wisconsin the introduction of pouring devices is said to have made it possible to lengthen the molding period by over an hour each day, resulting in an increase in production of nearly 20 per cent, accompanied by a marked decrease in fatigue on the part of the men.

The fatigue element should not be overlooked in considering the installation of a mechanical pouring system. State laws regarding hours and conditions of labor are becoming more stringent every year, and the foundryman who does everything

he reasonably can to ameliorate the working conditions in his shop finds that he not only keeps on the safe side of legislative enactments, but usually, also, increases his profits owing to the more efficient work obtained from thoroughly satisfied employes.

Arduous and Disagreeable Work

There is no denying the fact that pouring-off a heat is exceedingly arduous and disagreeable work, even under the

FIG. 1—IN MANY FOUNDRIES THE METAL IS POURED INTO TROLLEY LADLES IN WHICH IT IS DISTRIBUTED TO THE VARIOUS FLOORS

best of conditions. In many cases, it has been found that machine or bench molders deliberately slow-up their production in order to make the labor of pouring at the end of the day a little easier, even though such tactics mean less earnings. It has been estimated that the energy expended by a molder in pouring-off an average floor of 150 molds containing ten

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pounds of metal each is equivalent to nearly half that required to make the molds on a swing head air squeezer machine. This excessive labor also is concentrated in a comparatively short space of time at the end of the day's work.

It is evident from the foregoing that the pouring problem is much more acute in foundries turning out large quantities of light castings than in shops pouring a similar tonnage of metal into a few large castings. In the latter case, the amount

FIG. 2—WHEN THE METAL IS DISTRIBUTED BY HAND, TIME FREQUENTLY IS LOST WAITING FOR IRON

of metal going into each mold is so large that crane ladles must be employed and the actual exertion required is greatly reduced. In some of these foundries 100 tons of iron may be poured into three or four castings, but in foundries specializing in automobile work, agricultural implement castings, sewing machine or typewriter parts, pipe fittings, etc., the pouring problem is a very real one. In one of the large automobile shops

FIG. 3—AN I-BEAM TROLLEY LADLE DISTRIBUTING SYSTEM IN A NEW ENGLAND FOUNDRY—NOTE THE AIR HOIST USED TO HANDLE THE DOUBLE-ENDED AUXILIARY POURING TROUGHS

in Detroit, for instance, an aggregate of 127.6 tons of iron per day is poured into 8,945 molds, giving an average of only 28.6 pounds of iron per mold.

A complete pouring system for a gray iron foundry handling comparatively light work should include apparatus for handling the metal at the cupola, for transferring it to the various floors, and for pouring it into the molds. But even today, in some shops, the practice continues of tapping the metal from the cupola into a bull ladle fitted with a geared tilting mechanism from which it is transferred to hand ladles for pouring into the molds. The hand ladles may be carried either by one or two men. The one man ladles will usually hold about 60 pounds of iron and the two-man ladles, from 125 to 230 pounds. In most foundries at the present time, however, some arrangements are made for transferring the molten iron from the cupola to the floors by mechanical means, even though the actual pouring may be done by hand. Where the average weight of the castings is comparatively large, over 50 pounds, crane ladles of from one to four tons capacity, handled by the regular traveling crane are fairly satisfactory. The crane transfers the metal to the extreme ends of the shop very quickly and usually the plant is so arranged so that most of the floors are reasonably accessible from the crane runway. In these cases, the metal usually is tapped directly from the cupola into the crane ladle. For lighter work and where more than 400 molds must be poured daily, an overhead trolley or industrial track system is preferred for distributing the iron, because the traveling crane can handle only one ladle at a time, whereas the trolley or track system can handle ten or a dozen if necessary. With the latter system, also, it is easier to reach remote portions of the floor.

Overhead Trolley Distributing System

Although truck ladles, running on narrow gage tracks, are used very successfully in a number of shops, the tendency seems to be toward the employment of overhead trolley systems for distributing the metal. The trolley system has the advantage of saving floor space. Also its first cost is low and it is easy to manipulate. Many successful trolley systems are home-made, using plain I-beams and improvised trolleys.

FIG. 4—MONORAIL DISTRIBUTING SYSTEM IN FRONT OF BATTERY OF FOUR CUPOLAS IN THE FORD FOUNDRY

It is generally believed, however, that more satisfactory results can be obtained by purchasing this apparatus from manufacturers who specialize in trolley equipment.

A typical trolley system used for distributing hot iron is shown in Fig. 4, which illustrates a portion of the gray iron foundry of the Ford Motor Co., Detroit. Two 72-inch and two 60-inch cupolas are provided. They are located in the middle of the shop, which is 581 feet in length. A double track I-beam monorail leads in each direction from the

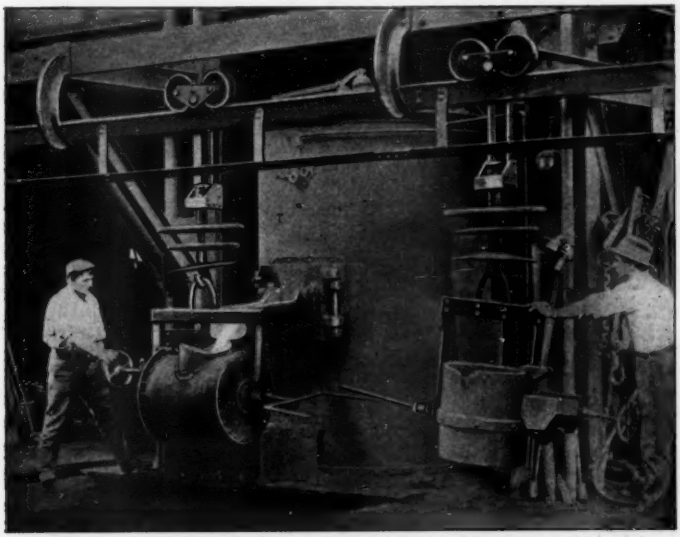

FIG. 5—CYLINDRICAL TROLLEY LADLE USED IN A GERMAN FOUNDRY

cupolas to the various molding units and floors. Suitable loops and switch connections are provided in front of the cupolas as shown in the illustration. Geared tilting ladles of about 2,000 pounds capacity are operated on the monorail systems, the iron being tapped directly from the cupolas. Each of the four continuous molding units in the shop is provided with a subsidiary trolley system from which the molds are actually poured, the large gear-tilted ladles operating on the main I-beam monorail being used simply to transfer the metal.

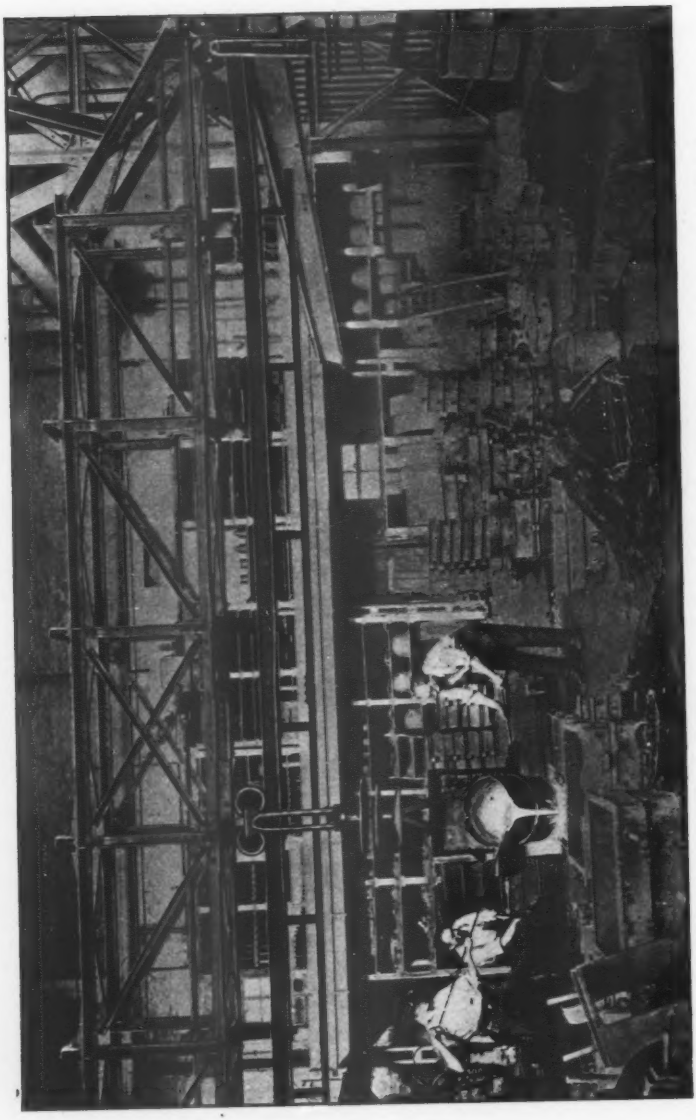

FIG. 6—TRAVELING BRIDGE USED FOR POURING MOLDS IN A GERMAN FOUNDRY

A German trolley ladle system is shown in Fig. 5. It will be noted that one of the ladles is cylindrical in form and is tilted by a spur gear mechanism. This ladle has a capacity of 1,320 pounds of iron and weighs 88 pounds when empty. A traveling bridge used for pouring molds in another German foundry is shown in Fig. 6. In this case the bridge carries

FIG. 7—PORTION OF TROLLEY TRACK FOR DISTRIBUTING METAL IN A WESTERN IMPLEMENT FOUNDRY

a monorail on which the ladle trolley operates, the bridge connecting with an extensive trolley system which reaches all parts of the shop. A 2,000-pound ladle is employed.

Another interesting trolley system, installed in the plant of the Emerson-Bramington Co., Rockford, Ill., is shown in Fig. 7. This plant is designed for a capacity of 65 tons of light gray iron agricultural castings per day, the molding floor

being 245 feet long and 124 feet wide. The heaviest castings do not weigh over 150 pounds, while the lightest pieces tip the scales at less than eight ounces. The average weight of the castings produced is only 4½ pounds; 75 molders are employed. One trolley track extends the full length of the shop through the north aisle, while a similar one covers the south aisle. Both of these are so situated that they also serve the center bay. A special truss carries a connecting trol-

FIG. 8—CUPOLAS AND POURING ARRANGEMENTS IN A WESTERN CONTINUOUS FOUNDRY

ley track across the middle of the shop. Small hand ladles are used to transfer the iron from the trolley ladles to the molds and each molder pours off his own work.

The arrangements for pouring metal by means of trolley ladles in the continuous foundry of French & Hecht, Davenport, Ia., are shown in Fig. 8. In this shop the molding machines are arranged around the circumference of a rigid circular mold conveyor which operates on a track, 85 feet in diameter. The cupolas are situated alongside one section of the mold conveyor and the molds are poured as they pass

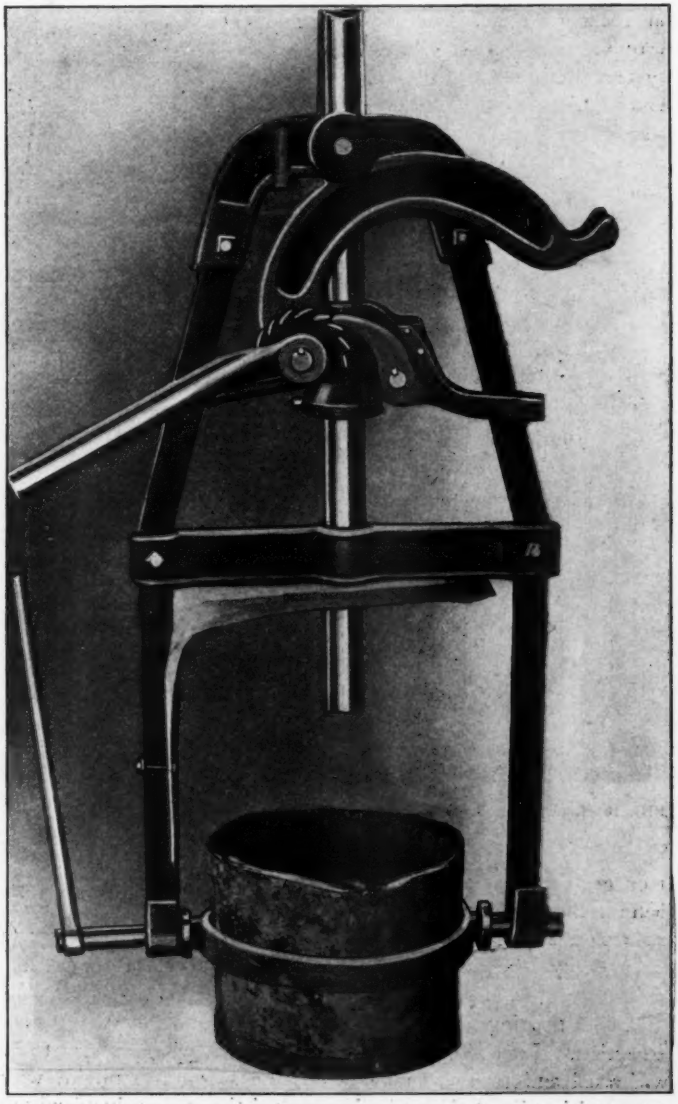

FIG. 9—POURING DEVICE INVENTED BY HENRY ARIENS

in front of the furnaces. The cupola spouts are short and lead to small receiving ladles which are tilted by means of a system of levers. An eliptical monorail, shown at *M* in Fig. 8, extends around behind the cupolas, over the tilting ladles and also covers a segment of the circular mold conveyor. Four trolleys are operated on the monorail and from each one a 120-pound pouring ladle is suspended. Each pouring ladle is handled by one man, a gang of four being employed. The

FIG. 10—BATTERY OF POURING DEVICES IN FOUNDRY OF BRILLION IRON WORKS

men get their loads of hot iron from one of the reciving ladles behind the cupolas. Although the work is arduous, it is not so severe as might be expected, inasmuch as the trolleys run very easily and carry the entire weight of the ladle and the iron.

The pouring ladle shanks are rather ingenious in construction. Instead of the usual forked end, which is said to be awkward and tiring to manipulate, the shank is straight, with a turned handle at the end. To control the ladle a hand wheel,

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18 inches in diameter, is provided at about the middle of the shank. It is grasped with the right hand and is used to steady and tilt the ladle as required.

As mentioned previously, in many shops the iron is delivered to the various floors by truck or trolley ladles and transferred to hand ladles for the actual pouring. But where a

FIG. 11—TRANSFERRING METAL FROM DISTRIBUTING LADLES TO SPECIAL POURING LADLES

large number of molds are made, hand-pouring, even when the iron is distributed by trolley ladles, results in reduced production. Therefore, an acute need has arisen for a suitable pouring device which will be universal in its application and will serve the entire molding floor area. A number of devices have been designed to meet this situation, a few of which will now be described.

FIG. 12—POURING DEVICE USED BY KING SEWING MACHINE CO.

An interesting pouring device designed particularly for gray iron or malleable foundries turning out light castings is shown in Figs. 9, 10 and 11. It was invented by Henry Ariens, president and general manager of the Brillion Iron Works, Brillion, Wis. Where this device is used, the iron is distributed to the various floors either by a trolley ladle or by some other means. Each floor or bay is equipped with a small, easily-operated hand crane which runs across the shop at right angles to the distributing ladle track. The hand crane carries a small ladle from which the molds are poured. In most shops the cupolas are located near the middle and the distributing ladle, which is generally electrically-driven, making alternate trips to each end of the molding room. Usually an operator rides with the distributing ladle and controls the filling of the small pouring ladles. The latter are handled entirely by the molders, who not only pour-off the floors, but in some shops shift their own weights and clean up the scraps of iron which may be spilled. The general arrangement of the system is clearly shown in Fig. 10, while Fig. 9 gives a detailed view of one of the pouring ladles.

The hand crane which carries the pouring ladles may be of any convenient span up to 20 feet. At the Brillion shops these cranes have a span of 15 feet and a height of 8 feet from the floor. The latter figure could be increased to 12 feet with safety. The hand crane consists of simple roller-bearing trolleys, between which a 5-inch I-beam is suspended.

The pouring ladle yoke is hung at the lower end of a 1¼-inch pipe, as indicated in Fig. 9. The ladle itself is carried in a bail, to the shaft of which the tilting lever is attached. The yoke slides over the suspension pipe and rests on a large cam which is held in position by a pawl. When the pawl is released, the yoke and ladle may be raised or lowered a distance of 10 inches by operating a lever connected to the cam. When receiving metal from the distributing ladle, the pouring ladle is brought to its lowest position and is afterward raised to any height convenient to the operator, within the range of the device. A sheet metal shield, which is secured to the yoke over the ladle, screens the molder's eyes from the intense

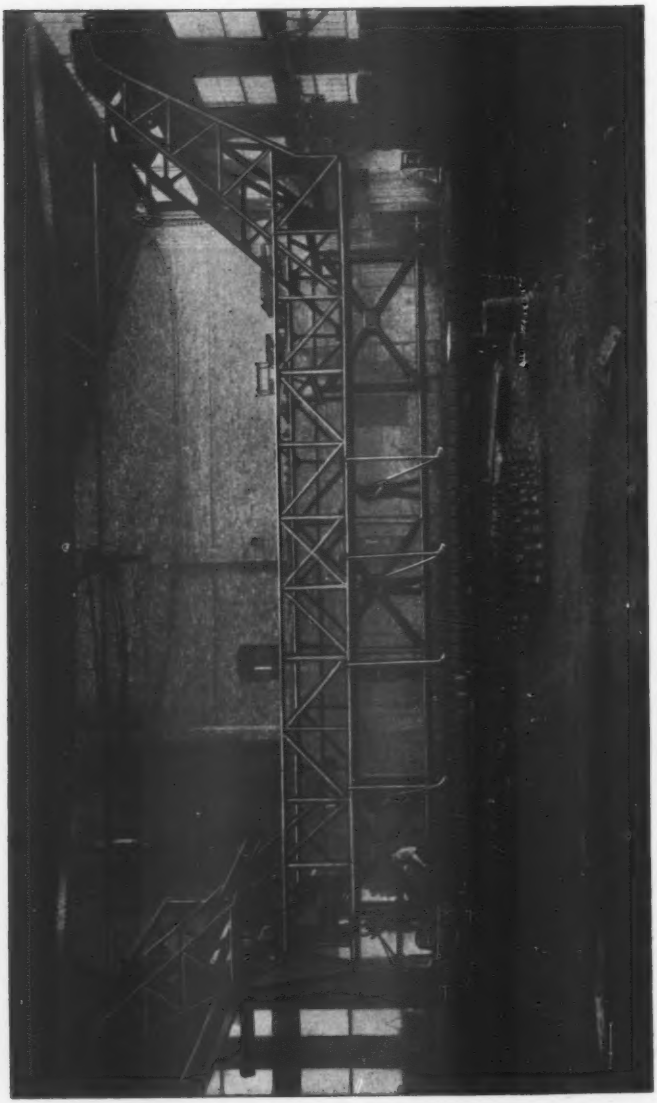

FIG. 13—POURING BRIDGE USED IN A LARGE MIDDLE-WESTERN FOUNDRY

glare of the hot iron. This results in more accurate pouring and fewer spills, thus reducing accidents and burns to a minimum. The men also appreciate the relief from eye strain.

When using this device, it is stated that one man easily pours 175 molds containing castings weighing 16 pounds each, including sprues. The total weight of metal poured by one man is, therefore, approximately 2,800 pounds. It is said an even greater number of smaller flasks can be poured and under favorable conditions the records given above may be improved upon.

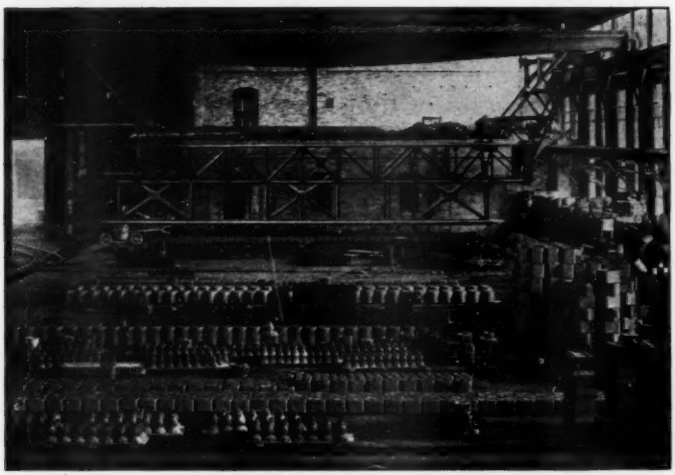

FIG. 14—ANOTHER VIEW OF THE POURING BRIDGE SHOWN IN FIG. 13, SHOWING THE ARRANGEMENT OF THE MOLDS ON THE FLOOR

Ladles Vary in Size

Owing to the fact that the distributing ladle usually is so operated that it makes alternate trips to each end of the shop, the men have ample time to shift their weights and rest during the pouring period. The distributing ladle may be of any convenient size. Usually it carries 2,000 pounds of iron, the small pouring ladles having varying capacities up to 300 pounds. The molds are poured in rows commencing with the one farthest from the distributing ladle.

In a series of observations made at the Brillion plant on Feb. 12, 1914, it was found that a green molder poured seven flasks containing 15-inch clod crusher plate castings in 160 seconds. The total weight of metal handled in this time was approximately 90 pounds. About 25 seconds were required to fill the ladle and shift the hand crane to the proper point for pouring; 65 seconds were absorbed by the pouring operation itself and 70 seconds more in shifting weights and returning

FIG. 15—CAR DRIVEN BY STORAGE BATTERIES, USED FOR HANDLING BUGGY LADLES

the pouring device to the distributing ladle. It is stated that when pouring by hand the men were able to carry enough iron to fill only three molds at a time and that a helper was necessary to shift the weights. It will be noted that the molder is relieved of all of the heavy labor of pouring.

The distributing ladle at the Brillion plant is suspended from an electrically-driven I-beam trolley, and is steadied at the bottom by a trailing wheel. A 9-inch I-beam is used and a 2,000-pound gear-tilted ladle is carried. The machine is driven by a four-horsepower reversing motor.

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Another pouring device, somewhat similar to the one just described, is employed in the shop of the King Sewing Machine Co., Buffalo, N. Y. It is shown in Fig. 12, which clearly outlines its construction. It consists simply of a suitable trolley to which a suspension rod leading to the ladle yoke is attached. The suspension rod is provided with a turn-buckle so that the height of the ladle may be adjusted. The ladle yoke is carried by a ratchet lever which is used to adjust the

FIG. 16—THE BUGGY LADLE IS HOISTED BODILY FROM THE FLOOR FOR POURING

ladle to the exact height required after the approximate height has been fixed by the turn-buckle. This device is used either with 250-pound or 500-pound ladles.

An exceedingly interesting pouring device suitable for shops having a large amount of small repetition work is shown in Figs. 13, 14, 15 and 16. Its essential feature is a traveling bridge which is suspended from the main crane runway. This bridge, therefore, commands the entire molding floor and the metal is poured from small ladles which are suspended from light hand trolleys running on a track secured to the lower

truss chords. The bridge also carries a platform on which the men controlling the pouring ladles walk. The pouring ladles are suspended by means of a chain link which permits of tilting them in any direction; the ladle also is securely fixed to a long tilting handle or shank, which is controlled by the workman.

The small pouring ladles are filled from a buggy ladle shown at the left in Fig. 13. When the device is in operation, the men fill their pouring ladles from the buggy ladle and walk out on the bridge to the molds which are to be poured. The trolley track is looped and as soon as the molds are poured, the workmen return with their empty ladles to the point where the buggy ladle is located. The men, therefore, walk completely around the platform under the bridge, pouring the molds rapidly. As each row is poured, the bridge is advanced to the next row. A special hoist is provided which lifts the buggy ladle bodily off the floor for filling the pouring ladles.

The buggy ladles are transferred from the cupola to the pouring bridge by the electrically-driven car shown in Fig. 15. The cupola is provided with a double-lip pouring trough which is mounted on trunnions and may be tilted in either direction. Two buggy ladles are usually placed under each trough so that when one is full the work of filling the other may commence immediately.

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The Structural, or Mechanical Theory of the Effect of Rust on Cast Iron and Wrought Iron and Steel

By R. C. McWane, and H. Y. Carson, New York

From out the maze of chemical controversy of recent years as to the cause, or causes, of rust, stands the fact that cast iron resists the action, or actions, that prove so quickly and so completely destructive to wrought iron or steel, and with this fact chemists have never yet been able to reconcile their theories.

In all the chemical, or electro-chemical theories so far advanced, cast iron has been shown to be most susceptible to rust, because of the larger percentage it contains of foreign matter, such as graphite, silicon, manganese, sulphur and phosphorus, yet the facts of history prove that while cast iron will become quickly coated with rust, it will remain practically unimpaired in weight and strength for hundreds of years under conditions that prove absolutely fatal to wrought iron or steel in 10 to 20 years.

These facts indicate, therefore, that we must look to other than chemical causes for a satisfactory explanation of the phenomenon of rust damage, and the theory which seems to be most nearly in harmony with the facts, but which has received scant attention in the discussion of this subject heretofore, is that of the marked difference in *structure* between cast iron and wrought iron and steel.

This difference is graphically shown in Figs. 1 and 2, these illustrations being reproductions of actual photomicrographs.

Whatever may be the accepted theory of the actual process of rust, whether the hydrogen-peroxide, the carbonic acid or the electrolytic, the three most generally accepted theories at present, it is unanimously agreed that the process is a form of slow combustion, with the presence of oxygen as an all-

important factor, and that if the material can be fully and permanently protected, to exclude oxygen, rusting will not take place.

Structure of Cast Iron

By reference to Fig. 1, it will be noted that cast iron has a distinct granular, or crystalline structure, a form common to all metals having undergone the simple process of smelting and cooling, which was one of the processes of nature in the formation of the ore, and it is this distinctive structure, in combination with the chemical, or electro-chemical, action taking place on the surface of the metal, which serves to stop that

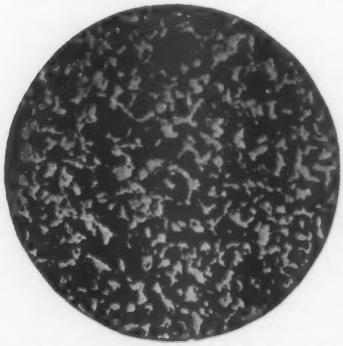

FIG. 1—PHOTOMICROGRAPH OF CAST IRON

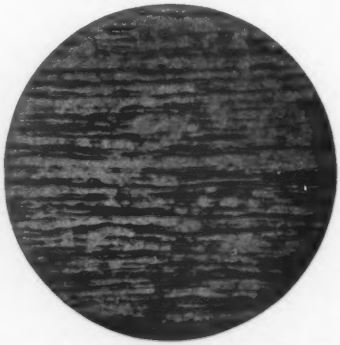

FIG. 2—PHOTOMICROGRAPH OF WROUGHT IRON

action after it has proceeded to a certain depth, and hold the result (ferrous oxide) as a permanent, oxygen-excluding protective coating. This stoppage of rust action results from the fact that the crystals, or granules, in cast iron are bound together at one or more points by a metallic bond, or bonds, and after a rust coating has been formed of the loose crystals on and near the surface of the metal, and the oxide penetrates between the crystals more strongly bound together, the force exerted by the absorption of moisture is not sufficient to separate the crystals, and the oxide remains as a permanent coating.

The undisputed fact that from the moment we begin to manipulate cast iron by puddling and rolling, we lay down the barriers for the invasion of rust, and the further well-known

fact that the thinner a sheet of wrought iron or steel is rolled the more rapidly it will succumb to the action of rust, leads inevitably to the conclusion that the change in structure brought about by such manipulation has a most important, if not altogether final, bearing on this much discussed question.

Passing over the intermediate processes, from cast iron to the extreme of thinly rolled sheet steel, we find the structure of the metal to have changed from crystalline to fibrous and finally to distinct laminations, or leaves, and in each process of heating and rolling the natural bond found in the crystalline structure of cast iron has been further disturbed, until in the steel sheet we find the leaves bound together largely, if not altogether, by the force of compression, yet distinctly

FIG. 3—DRAWING OF A PIECE OF SHEET STEEL, MUCH ENLARGED, SHOWING SURFACE AND SECTIONAL STRUCTURE WITH A TYPICAL PIT

differentiated one from the other by the very small percentage of silicon always present but uncombined with the steel.

The rusting of steel is evidenced by a form of pitting and exfoliation, or flaking-off of minute particles of metal, exposing a new surface for attack, from time to time, until the entire section is affected. This can be clearly understood by reference to Fig. 3, which is from a drawing made to represent a piece of sheet steel, very much enlarged, showing a surface and sectional structure, and a typical *pit,* which is likely to occur at various points in sheets apparently well-protected with paint or other coating. Uncoated sheets will scale off much more uniformly, and despite the claims of various manufacturers in the past few years of having produced a coating that will successfully and permanently adhere to the smooth surface of

rolled steel, rust damage to such steel goes on apace, especially in locations where it cannot be watched and the coating frequently renewed.

An important factor in the scaling-off or breaking up of the surface of rolled steel, and one which has never been considered heretofore, would seem to be the forces of expansion and contraction as offering a reasonable and satisfactory explanation of the rapid deterioration of such steel when exposed to sudden and violent changes in temperature. These changes, taking place on the surface of the metal before the interior portions are affected, tend to buckle, or stretch, the

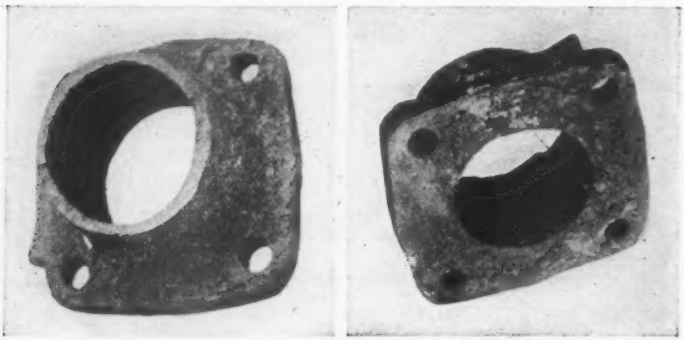

FIG. 4—PIECES OF CAST IRON PIPE FROM AN UNDERGROUND LINE INSTALLED BEFORE 1685

surface metal and to tear the laminations apart or open them up so that rust action is accelerated.

The change in structure from a crystal of appreciable size, bound to its fellows by a metallic bond, to an infinitesimally thin leaf, with no bond strong enough to resist the efforts of the rust coating to tear it away from its fellows, is a thoroughly understandable and logical explanation of the effect of rust on the two materials, and is not in any way weakened by the well-founded claim that "old-fashioned wrought iron" resists rust to a remarkable degree.

The early and crude methods of making wrought iron, while producing metal of greater tensile strength than cast iron, accomplished the desired end by increasing the density

of the structure through hammering or forging, making little change in the shape of the crystals and, above all, *not destroying the natural metallic bonds* between the granules of iron. Structures such as link chain bridges, erected more than 100 years ago, have been referred to as instances of the power of wrought iron to resist rust, yet links taken from these bridges, showing no sign of deterioration from rust, have been heated and rolled by modern processes and found to rust as rapidly as ordinary steel plates. On the other hand, rolled steel plates may be cut up, remelted and made into steel castings, thus restoring the natural bonds in the crystalline structure, and it is found that they resist rust almost as well as cast iron.

FIG. 5—EFFECT OF RUST ON CAST IRON

FIG. 6—EFFECT OF RUST ON WROUGHT IRON

No more striking illustration of the lasting, or rust-resisting qualities of cast iron is afforded than the pieces of cast iron pipe shown in Fig. 4, the photographs having been taken in Paris, France, in 1909.

These pieces of pipe are from an underground line installed prior to 1685 for the purpose of conveying water to the famous fountains in the Versailles Park, and official report says that when taken up this pipe was "in apparently as good condition as when installed".

Figs. 5 and 6 illustrate the relative effect of rust on cast iron and wrought iron. The cast iron shown here was used in the same service with the wrought iron and for the same length of time, and shows no sign of deterioration, while the wrought iron is completely destroyed.

FIG. 7—WROUGHT IRON AND CAST IRON PIPE COUPLED TOGETHER FOR SERVICE TO COMPARE DURABILITY

FIG. 8 — THE WROUGHT IRON PIPE, SHOWING EFFECTS OF CORROSION

FIG. 9—THE CAST IRON PIPE, STILL SERVICEABLE

Paper by H. Y. Carson

Perhaps no field affords a better means of studying iron pipe corrosion at first hand than pipe contained in the plumbing of buildings. First, this is due to the fact that both wrought iron and cast iron pipe have been installed and used in the waste lines of buildings during the past 20 years; second, old buildings are continually being torn down or remodelled, so that it is possible to obtain specimens of cast iron pipe which have been in the same service with wrought iron and steel pipe; and third, when such a pipe line fails the sewer gases escape from it and render poisonous the atmosphere of the building.

Corrosion in waste and vent pipes is attributable to the moist condition of the air within the piping system, together with the hydrogen sulphide (H_2S) and carbon dioxide (Co_2), products of bacterial decomposition of sewage, which may be considered as dilute acid reagents attacking the internal surface of the pipe. Such are the normal conditions analogous perhaps to the damp air of cellars where it is so common to note the corroding of iron taking place at a fairly high rate. In many drains and vents the corrosive action is found to be even more severe than this. Where hot water or steam is discharged into the waste pipes, or where strong acids, disinfectants or other strongly corrosive substances are discharged along with the waste water into the lines, the corrosion of wrought iron or steel becomes far more rapid and the lines break down in 5 to 10 years after being first put into use. To explain the wide difference that exists between the life of cast iron pipe and wrought pipe, none of the commonly discussed theories can be made to fit the facts of actual service. Indeed, they are in direct opposition to the facts.

Typical is the comparison offered by the installation illustrated in Figs. 7, 8 and 9, which gives an actual comparison of the durability of cast iron and wrought iron soil pipe joined

together and used in the same 5-inch drainage stack for 18 years.

The wrought iron pipe in all cases indicates a continuous peeling off of rust scales, until the whole section is destroyed, while cast iron pipe is unimpaired by the same corroding action which destroys wrought pipe. The cast iron pipe shows, when removed, a closely adhering rust coating on the surface, which undoubtedly prevents the destruction of the pipe. The loss in weight and original thickness of cast iron pipe by 18 years of service was something less than 1 per cent, while that of the wrought iron pipe was more than 72 per cent. It is not unlikely that the greater part of the 1 per cent loss in cast iron pipe actually took place during the first year the pipe was put into use, since this pipe is not tar-coated, and it is well-known that the surface of uncoated cast iron pipe corrodes very quickly. It is probable that uncoated cast iron pipe will show a higher initial loss by corrosion during the first few months of service than would be shown in the wrought iron or steel pipe subjected to the same corrosive action during the same period of time.

Observing the manner in which all rolling mill products corrode, we must necessarily attach a great deal of importance to the microscopic structure of the iron. The same typical flaking-off of rust scales may be observed on rolled steel beams, round or square bars, or any other of the many products which are turned out of the modern rolling mill. In every known case the material showing this typical flaking-off has a rolled, laminated structure, in which the natural bonds between the existing, but deformed, granules of iron are completely destroyed or weakened beyond the point at which they can successfully resist the action or actions of rust.

Ancient wrought iron or steel, and even that made 100 years ago, is known to have resisted corrosion much better than the modern wrought iron or modern rolled steel. This can be explained by the fact that old iron does not have the same physical structure as the modern milled product, because ancient iron was smelted from the ore by crude methods into small-size pieces of metal and then hammered—not rolled—into its finished shape. Had the ancient iron been manipulated like the

modern rolled steel, it could not have lasted more than a few years.

These facts lead to the obvious conclusion, namely, that iron which has a granular or crystalline structure in which the natural bond has not been disturbed by mechanical manipulation, is more resistant to corrosion, regardless of its chemical content than iron or steel in which an attempt has been made, after rolling, to restore the crystalline structure by annealing or other processes.

Discussion

THE CHAIRMAN, MR. B. D. FULLER:—This able paper brings up a question which possibly is quite interesting to a number of you. I guess we have all been up against the troubles of corrosion in steel and wrought iron. Has anybody any questions?

MR. A. B. ROOT JR:—I would like to ask the speaker if, in the course of his study, he has found that the difference in structure of different cast irons make any difference in the rust-resisting qualities, and if there are any tests which may be made to determine that difference if it exists?

MR. R. C. MCWANE:—You mean by the difference in structure, the difference in the size of the crystals, the closeness of the grain?

MR. A. B. ROOT JR.:—The microscopic determination indicates different structures of different cast irons, and I am wondering if tests have been made which would show the different effects on those different structures.

MR. R. C. MCWANE:—Not so far as I know.

MR. A. B. ROOT JR.:—Are there standards that could be followed in making tests?

MR. R. C. MCWANE:—Not so far as I know.

THE CHAIRMAN:—The idea advanced in the paper of the laminated structure of steel and cast iron and the binding struc-

ture of cast iron, I confess is a new idea to me; probably it is the explanation of the difference in the life of the three materials.

MR. J. H. HOLMGREEN:—I would like to ask the speaker whether he found any difference in the action of rust upon strictly cast iron from that of cast iron and steel mixed, the so-called semi-steel?

MR. R. C. MCWANE:—I might say in answer to that question, that all of the tests that have been made along this line in the past few years have been tests of only weeks or months and have not been of sufficient length to get a result in a really decisive manner.

MR. J. H. HOLMGREEN:—Over an extended length of time?

MR. R. C. MCWANE:—Not over an extended length of time. I might also say that I believe that the sulphuric acid test has been entirely given up or eliminated by those who have given any great amount of study to the matter, for the reason that it has been shown that the open structure of cast iron renders it much more easily consumed by sulphuric acid of certain strength than the dense structure of steel or wrought iron. One of the favorite tests, of course, on the part of the steel people, has been to use a solution of sulphuric acid, placing a piece of cast iron in one solution and wrought iron or steel in the other; of course the cast iron suffers very quickly, and I think it has been generally decided or accepted that the reason for that is the open structure of cast iron, the fact that the acids can penetrate it so much more quickly. I might also call your attention to some recent tests made in Great Britain by some members of the British Iron and Steel Institute on the relative corrodibility of gray cast iron and steel and so far as these tests go, they seem to bear out the theory presented in this paper. I want to call your particular attention to the statement in regard to the effect of expansion and contraction. In test No. 1, with ordinary tap water during a duration of three months, the loss in steel, in weight of steel, was 0.1886 and in cast iron 0.2208. We admitted that cast iron will lose more initially than steel, which of course is shown by this test. In test No. 7, in alternating hot and cold water, 11 weeks' test,

just a week short of three months, we find that the loss in steel was 3.2142, while the loss in cast iron was 0.2174.

MR. R. F. HARRINGTON:—Bearing out the speaker's statement in regard to the acid and alkali test on cast iron, I wish to state that I had occasion to look up this matter, and aftetr poring over volumes and volumes of literature, both of the American Society for Testing Materials and of the American Chemical Society, I found that the test no longer was recommended by either society. I would, therefore, ask if any of the chemists here, or men interested in that line of work, have found a really satisfactory method for testing for corrosion, either alkali, acid or rust?

THE CHAIRMAN:—Perhaps Dr. Moldenke can answer that question if you will put it again?

MR. R. F. HARRINGTON:—Our speaker has just told us that in his investigation of the rust question on wrought iron, steel and cast iron, that he has been unable to find a method suggested for the acid or alkali test, and that in his readings he had found that the tests, as previously outlined by the American Society for Testing Materials, had been given up, having proven wholly unsatisfactory. I stated that I had also found, after going over a great number of records of the American Society for Testing Materials, and especially the last few bulletins, that that society is giving up the test, their bulletins stating that as yet no entirely satisfactory method had been found, especially in connection with cast iron. I also asked if anyone present had a method that he was employing in routine laboratory work that was proving satisfactory, comparatively, at least, for either acid or alkali test.

DR. RICHARD MOLDENKE:—I had hunted up that very question myself within the last few weeks, and was rather astonished to find almost nothing. I believe this comes from the reason that the question of electrolysis has been studied but recently. I have obtained samples from many parts of the world and I could cut most of the castings with my knife. The metal is simply oxidized, likely through the agency of moisture and earth currents near electric light stations and around railroad yard signal systems. The question of rust under *normal* conditions is not so serious as one thinks. The

loss of cast iron amounts to but one-tenth of an inch in a century, and when it comes to an atmosphere near salt water it may run as high as 4/10-inch in a century. Today, however, we have cast iron pipe in regions where there are stray earth currents, which is gone in two years. There is no way of testing this out, but there is necessity for preventing it by proper coating, so that the metal may not be exposed to moisture and currents at the same time. While the situation is absolutely unsatisfactory, yet it shows more and more that cast iron is the ideal thing to use for water and soil pipes and not steel, as it has practically double the life there is in steel.

MR. R. F. HARRINGTON:—Perhaps Dr. Moldenke will have some ideas in regard to the rusting of semi-steel as compared with straight gray iron.

MR. J. H. HOLMGREEN:—I put the question whether the action of rust upon the so-termed semi-steel cast iron and steel melted together—whether that was more susceptible to rust than cast iron? Taking it from the gentleman's paper, I should judge that it would not be, where the work is done from a fluid to a solid stage by crystallization—I believe that is the idea I got—whereas, where the material is produced by forging or rolling, it becomes of a fibrous nature, laminated nature, and is attacked much quicker. Now the question I would like to ask is whether the semi-steel water works fittings which I am making, and which contain 15 to 20 per cent steel, although stronger and tougher than straight gray iron, will last as long as gray iron when exposed to moisture?

DR. RICHARD MOLDENKE:—I think it is just the opposite; when you are adding steel to your mixture you are making a strong cast iron, not "semi-steel".

MR. J. H. HOLMGREEN:—I say, so-called semi-steel.

DR. RICHARD MOLDENKE:—You are right; the mistakingly called "semi-steel" goes back to the fundamental question of what gray cast iron is. It is nothing more than a crystallization of steel with graphite placed between the crystals. If you take an analysis of cast iron, you will find silicon, manganese, phosphorus, etc., if the combined carbon runs, say, 0.20, and graphite, 3.50. It means that that is a 0.20 carbon steel with 3.50 per

cent graphite shoved between the crystals. Now, what happens if you subject this metal to the action of rust, acids or alkalis? It means that you have got these crystals of steel with little spaces between them. The moisture water gets in between and consequently the steel goes very much faster than if the metal were sound. If you add steel to your mixture and thus cut down the total carbon, you will get a much denser material with fewer graphite spaces and it will last much longer by resisting the action of rust. The low carbon irons, in which the combined carbon is high and the proportion of crystals of graphite is small, will resist acid corrosion and heat better than soft gray iron with all those chances for moisture to get into the structure. It goes down to the fundamentals of cast iron. If you will only remember that this is a steel, and a bad steel, because of high phosphorus, etc., you will understand why a closer, denser iron has not the opportunity of being attacked by rust as easily as soft gray iron.

THE CHAIRMAN:—Gentlemen, I would like to hear Mr. Bradley Stoughton discuss this interesting question.

MR. BRADLEY STOUGHTON:—I have had some experience with these tests of cast iron and wrought iron and steel in reference to resisting corrosion, and I think there is not the slightest question that there is no reliable, rapid test. I do not think anybody would pay any attention to any test made today, because so many of them have been proven to be absolutely unreliable. At the exposition in San Francisco there are a number of exhibits of steel and wrought iron made for the special purpose of resisting corrosion, and those have been tested in various ways, but all of the makers, so far as I know, and it was a matter of business with me to investigate that matter, admitted the unreliability of any tests made in a laboratory. A number of tests are made, extending over a period of several months, steel and wrought iron being exposed to the atmosphere or exposed to fresh or salt water, but those are tests made to conform as much as possible to actual conditions and are not laboratory tests, and are not quick tests. I think it may be said positively that laboratory tests are entirely unreliable. Now, as regards the question of relative corrosion, my belief is that cast iron, with the skin on, is better than any of

the other products. If you leave the little skin put on the iron when it is poured into mold and then coat that, I believe it is better for resisting corrosion than either wrought iron or steel, but if you take the skin off, I think the evidence is, as Dr. Moldenke has said, that the cast iron will rust more rapidly than wrought iron and steel.

DR. RICHARD MOLDENKE:—I made some tests one time on the corrosion of cast iron when I was in the malleable business, particularly in regard to the action of hydrofluoric acid. I had castings hanging continuously in baths of hot, diluted hydrofluoric acid, while putting through about 25 tons of small work daily, and did not notice the slightest sign of any action whatever on those castings, which was simply because they were white iron. It was a solution of 1 to 30 and attacked the gray iron all right. So you will see the value of closing up the cast iron and having so little chance for the acid to get in as possible, white iron is the very best thing for the purpose.

MR. R. F. HARRINGTON:—Bearing out Dr. Moldenke's theory again, in looking up that matter, I went over some papers of the American Society for Testing Materials and found that Dr. Miller, of the Institute of Technology, had done some work on that in connection with another gentleman whose name I have forgotten, and he took three products, gray iron, semi-steel and an air furnace iron. He found that the low carbon product resisted both superheat and rust better than the soft gray iron.

MR. A. O. BACKERT:—Bearing out Mr. Stoughton's statement regarding the skin on cast iron, I recall some tests made several years ago by Edgar Allen Custer. You probably know something about his process of casting in permanent molds. He was making cast iron soil pipe in permanent molds at that time, and casting the iron against the so-called chill gave it an unusually thick skin, and he made a lot of corrosion tests—you might call them accelerated corrosion tests—by subjecting the soil pipe cast in permanent molds to salt water, sulphuric acid and, I think, hydrofluoric acid tests, and then he also subjected ordinary soil pipe to these corroding influences. The pipe cast in permanent molds resisted corrosion far better than pipe cast in sand, and I think that helps to bear out what Mr.

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Stoughton has just said about the skin on cast iron. It also might be interesting, in this connection, to find out what effect the sand blast has on the removal of that skin, or to what extent it penetrates the surface of cast iron.

DR. RICHARD MOLDENKE:—Can I ask the speaker what he means by "skin"?

MR. A. O. BACKERT:—It seems to be a sort of resisting outer coating on cast iron.

DR. RICHARD MOLDENKE:—There is certainly a peculiar coating on castings that comes from the oxidation of the surface, etc., but when you speak about casting against a chill this means that the first eighth inch of that metal at least is of a different structure altogether than if cast in sand. You have a higher combined carbon because you remove the heat faster than when you cast in sand. Therefore, there is less chance for moisture penetration. That is why, when they sand-blast castings, they come out clean with the skin intact. With acid cleaning there is a difference in how far the action goes on under the skin, the interior being very much more open than the metal near the surface.

MR. A. O. BACKERT:—Following out your argument, what is the comparative corrosion of a chilled iron as compared with an ordinary gray iron?

DR. RICHARD MOLDENKE:—Carrying it out to the extreme, when you make white iron, you have got it all skin.

MR. IRA B. LESCH:—I think that all anyone needs to do to determine that question is to go to a wheel foundry and look over a pile of wheels that have been out in the weather three or four years; you will find different threads as bright as when they were cast, while the plates will be rusted; that will determine just what the effect of a chilled surface is.

DR. RICHARD MOLDENKE:—Go to a place where they make glass molds, which are of metal very high in silicon, which is chilled, but not white. They grind the inside surface where the glass comes in contact with the molten metal. I have seen piles of these castings rusted on the outside, with the inside retaining its perfect polish. They had been exposed to the weather nearly a year. This is gray iron, but has been made

dense by pouring it around a chill, and yet there is no white iron in it, because the silicon is too high.

MR. A. O. BACKERT:—How about the sand blast, Doctor?

DR. MOLDENKE:—I cannot say for the moment.

THE CHAIRMAN:—Pardon me, Doctor; I can only say from my experience that a sand-blasted casting will show corrosion quicker than one which has not been sand-blasted. When making shipments of sand-blasted castings on flat and open cars, we get complaints very quickly, particularly if they have passed through a rain a few hundred miles, whereas no complaint is made of castings shipped in this way which have not been sand-blasted. I suppose sand-blasting simply takes off that much of the outer skin.

DR. RICHARD MOLDENKE:—The sand blast would remove any graphite or a sand and slag skin on the surface and it naturally will rust more quickly.

MR. F. N. SPELLER[1]:—These papers on the corrosion of cast iron and wrought iron and steel say nothing as to the graphitization, which causes a local disintegration of cast iron water and gas mains, which is the worst feature of the deterioration of cast iron, and something not found at all in steel and wrought iron. In claiming that cast iron is crystalline in structure, and steel laminated, the authors have adopted an erroneous premise for their argument which cannot be sustained for a moment. It is the rare exception to find a piece of laminated steel, on the contrary the steel structure is fundamentally crystalline and the individual crystals are much more closely attached and are more uniform in form than in cast iron. The close cohesion between the crystals is illustrated by the greater tensile strength of steel and wrought iron as compared with cast iron. The cases of ancient wrought iron referred to do not affect the case, for they have been found to owe this long life to an enamel-like flux or scale hammered into the surface. When this is broken by machining or filing, the metal has been found to rust like modern rolled iron.

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[1]Written discussion, submitted after the annual meeting. F. N. Speller is metallurgical engineer of the National Tube Co., Pittsburgh, Pa.

ALLERTON S. CUSHMAN[1]:—I have read these papers carefully. Both authors appear to have reached the conclusion that cast iron, under all corrosive conditions, is far superior to steel or wrought iron. They speak of all rolling mill products as being laminated in contradistinction to cast iron which has a granular or crystalline structure which makes it more resistant to corrosion regardless of its chemical composition. Nothing could be farther from the truth than these statements. Cast iron, to be sure, shows on fracture a coarsely crystalline surface, readily discernible to the eye. Rolling mill products, however, all have a highly refined crystalline, more or less finely-grained structure which is in no sense laminated unless the metal has been piled or fagotted and then re-rolled. Puddled wrought iron is sometimes spoken of as fibrous because it has slag lines rolled out in it, but when properly made neither wrought iron nor steel has a laminated structure. The fact that rust flakes on iron and steel often show a coarsely laminated structure is not due to the physical structure of the underlying metal, but to quite another reason which I have not the space here to go into. I have often found the rust on cast iron laid up in the same lamellar condition.

I have nothing to say against good cast iron, as I believe it to be a most excellent material for the purposes for which it is best adapted, and under such conditions it does well, perhaps better than any other metal, in resisting corrosive influences. The skin on cast iron is highly resistant to corrosion, although machined surfaces may be, in certain surroundings, very rapidly attacked. I should no more seek to draw invidious comparisons between cast iron and wrought iron and steel under all conditions than I would attempt to do the same thing as between wool, cotton and linen for use as clothing. I would not select cotton for my overcoat, wool for my pocket handkerchief or linen for my stockings. Yet all these materials may be relatively durable or relatively short-lived, according to the purity of the product, the care taken in the making and the purpose or service to which they are put. One advantage cast iron has for long life under corrosive conditions is its

[1]Written discussion submitted after the annual meeting. Mr. Cushman is director of the Institute of Industrial Research, Washington, D. C.

massiveness or thickness of wall. If cost considerations permitted rolled metal or even cast steel to be used in as heavy walled sections as cast iron, I doubt if under many conditions the advantage would lie on the side of cast iron, in spite of its resistant, silicious skin. A section of rolled metal twice as thick as another of the same analysis and structure will last much more than twice as long under most service conditions. I am inclined to think that longevity, due to thickness of gage, other things being equal, is more nearly in a geometrical than an arithmetical ratio. This is one of the reasons why all the examples of the ancient irons spoken of by one of the authors makes such a good appearance. We must not forget, however, that thin, beaten sections of ancient irons are rarely found, probably because they have rusted away. Nevertheless, I agree with Mr. McWane that the chemical purity of the old irons, as well as the surface puddling and densifying they got under the workman's hammer, were important factors in their wonderful resistance to corrosion.

I cannot agree with Mr. McWane in a number of his other statements, however; for instance, I do not believe in "ferrous oxide as a permanent oxygen-excluding protective coating", nor do I believe that "the crystals or granules of cast iron are bound together at one or more points by a metallic bond or bonds, and after a rust coating has been formed of the loose crystals on or near the surface of the metal, the force exerted by the absorbed moisture is not sufficient to separate the crystals, and the oxide remains as a permanent coating."

These words do not convey a perfectly clear meaning to me, but insofar as I understand them, they express quite opposite conclusions to those which I have reached after many years of careful study of corrosion problems.

I have made rolled sheets of 27 gage of the old pure iron links of chain bridges of one hundred years ago, and found them excellent resisters of corrosion in comparison with many types of modern rolled metal. Of course, if these were cut up and remelted into castings, as suggested by Mr. McWane, they would last much longer because presumably such castings would be much thicker than my rolled sheets. The fact remains, however, that no one can make a roof of cast iron

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nor a chain bridge out of cast iron links. In conclusion, I beg to refer to the fact that in what I have here set down I have had no intention of being controversial, but I have spoken merely for some of the many factors which enter into the discussion of corrosion problems, as I have observed them.

MR. H. Y. CARSON AND MR. R. C. MCWANE[1]:—It is interesting to note that Dr. Cushman apparently admits that cast iron in service has a much greater life than rolled wrought iron or rolled wrought steel.

Dr. Cushman's theory that the long life of cast iron pipe in service is due to a greater wall thickness than the rolled wrought iron is entirely disproven by the typical comparison illustrated in Figs. 7, 8 and 9, of our paper. This 5-inch cast iron soil pipe, Fig. 9, was used in the same service with the 5-inch wrought iron pipe, Fig. 8, joined together, as shown in Fig. 7. Both pipes were in place about 18 years and both, therefore, were subjected to the same service conditions. The original thickness of the wrought iron pipe was 0.258 inch; of the cast iron pipe, 0.25 inch; or in other words, the cast iron had an original wall thickness less than the wrought iron pipe. It is obvious, therefore, that cast iron does not owe its long life to greater wall thickness.

Moreover, this fact is borne out and emphasized by other important data. Prior to 1880, light weight *standard* uncoated cast iron soil pipe and fittings having a wall thickness of ⅛ inch, or less, were extensively used in buildings for the house drainage and vent systems. Thousands of these installations are still in use today. These cast iron waste and vent pipes are found upon removal to have suffered no appreciable deterioration. Such light weight cast iron soil pipe was removed in 1914 from the famous old Astor House, built by John Jacob Astor in 1834. These pipes, when removed, showed a closely adhering *oxygen-excluding protective coating* of rust on their interior surfaces, but absolutely no sign of a "silicious skin" spoken of by Dr. Cushman.

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[1]Written discussion submitted by the authors after the annual meeting.

On the other hand, both standard weight[1] and extra strong weight[2] galvanized wrought iron pipe, since 1890, has been installed for waste and vent lines in buildings. This wrought iron pipe or wrought steel pipe is showing evidence of being completely corroded-out by the gases generated in the sewage. Notable among the numerous cases which have come to the writer's attention, may be mentioned the Waldorf-Astoria hotel, New York, where the wrought pipe waste and vent lines have been completely destroyed in many places and are now being replaced at great cost to the owners. Equally impossible is it to agree with the statement made by Dr. Cushman that "if cost considerations permitted rolled metal or even cast steel to be used in as heavy-walled sections as cast iron, I doubt if under many conditions the advantage would lie on the side of cast iron, in spite of its resistant, silicious skin." Dr. Cushman apparently has overlooked a few facts. It is doubtful if a casting of iron or steel has ever been put into service without first having its skin surfaces removed in places. All castings after coming from the sand molds undergo a certain amount of cleaning, which removes the pouring gates, fins, etc. The castings are then filed or machined and this removes the skin surfaces at many points. By referring to Fig. 4, of our paper, it will be noted by observing the original pouring gates that such surfaces show no more deterioration than do the surfaces which originally contained a silicious skin. A careful examination of old castings has revealed the fact that rust action removes the outer skin of castings in a comparatively short time and that a permanent coating of rust forms on the denser structure beneath the silicious outer skin.

Dr Cushman mentions a comparison between the subject under discussion and the relative effect of "wool, cotton and linen for use as clothing". This implies that Dr. Cushman believes the three commercial iron products mentioned are three distinctly separate and unlike materials. In the first place, such analogies cannot hold for the reason that the iron products are made from one base, namely, iron ore. On the other hand, the clothing products mentioned are made from three distinctly

[1]Five-inch pipe, wall thickness = 0.258 inch.
[2]Five-inch pipe, wall thickness = 0.375 inch.

different base materials, wool, cotton and flax. In the second place, if Dr. Cushman can imagine the transfer of heat through a cloth medium as being like the progress of corrosion traveling through an iron or steel plate, an explanation would at once be afforded from his own analogy for the rapid destruction, or oxidation, of rolled iron as compared to higher resistance of cast iron, since the difference in structures between woolen, cotton and linen cloth could then be said to compare with the difference in structure between cast iron and wrought iron and steel.

It cannot be refuted that cast iron or cast steel in service behaves better than rolled iron or rolled steel as regards deterioration from rust. Likewise, it cannot be refuted that the structural formation of cast iron or cast steel, which undergoes a change from a liquid solution to a solid, is different from the structural formation of rolled iron or rolled steel in which the crystal formation takes place while the metal is plastic, or in a state known as *solid solution*. The evident proof of this is found in the fact, mentioned in our paper, that "rolled steel plates may be cut up, remelted and made into steel castings", and it is found that they resist rust almost as well as cast iron.

In conclusion, let it be clearly understood that the authors have no intention of recommending the use of cast iron for the links of chain bridges, the sole intention being to call attention to the important relation existing between the relative structures of cast and rolled irons and the effect of these relative structures on the rate at which the irons are reduced to rust in service.

Hardness Testing of Metals—A Review of Methods

By W. P. Putnam, Detroit

Ever since cast iron has taken an important position among materials of engineering and construction there has been felt the necessity of establishing some suitable means of determining the relative hardness of this important material.

The first apparatus designed for making hardness tests on metals came from Germany nearly a century ago and later perfected and described by Prof. Thos. Turner in an address delivered before the South Staffordshire Institute of Iron and Steel Works Managers, March 19, 1887. In this apparatus Prof. Turner employed weighted, octahedral diamonds which were drawn over the surface of the metal being tested. The weight in grams required to produce a scratch is the measure of hardness. Stoughton uses a constant weight and measures the width of scratch.

T. Egleston, of New York, describes a hardness testing machine in a paper read before the American Society of Mechanical Engineers and published in the Society *Transactions*, Vol. V. The machine was manufactured by Brown & Sharpe and measures the penetrability of the metal by drilling.

In 1896, A. Foppl proposed using cylinders machined to 20 mm. radius for hardness tests on metals. Two cylinders were arranged one on the other at right angles to their length and weighted until an indentation was made. The weight required to produce an indentation is the measure of hardness.

In 1897 Chas. A. Bauer, of Springfield, O., made a drill press into a testing machine for hardness testing. The drill press turned at 250 revolutions per minute and the drill was weighted with 160 pounds. A revolution counter was arranged to record the number of revolutions made by the drill in drilling ½-inch into the metal being tested.

Following the Bauer idea W. J. Keep, of Detroit, improved upon the Bauer machine by placing the working parts below the table, making the drill enter the metal from below to avoid friction. In this machine Mr. Keep uses a scale between 0 and 90 degrees automatically produced by the machine in drilling a hole to any required depth. This machine is described by Mr. Keep in a paper read before the American Society of Mechanical Engineers at New York, in December, 1900, and printed in the *Transactions* of the Society, Vol. XXII.

Not Hardness but Machinability Tests

Of all the machines mentioned, with the exception of Prof. Turner's, there can be raised the criticism of not being machines for hardness testing as we understand it today but rather machines to determine the machinability of metals. Prof. Turner's device seems to be the more rational instrument for hardness testing, but does not seem to have become a popular method. The other machines have had more or less success in practical use, but none is now being manufactured and seems to have been supplanted by the more recent types.

At the Paris meeting of the International Association for Testing Materials, in 1900, Prof. Brinell presented a paper on "Method of the Determination of Hardness and Ultimate Strength by Means of Ball Tests". The Brinell method, briefly stated, measures the hardness by means of steel balls pressed into the material being tested. A hardened steel ball of 10 mm. diameter is loaded to 500 or 3,000 kilograms in a suitable machine and the impression of the ball measured by the formula:

$$\frac{P}{A} = \Delta$$

In which P = Load; A = Constant; Δ = Hardness.

a = the surface of the "spherical calotte" produced by the steel ball and is determined by the formula:

$$A = \pi Dh.$$

$$a = \pi D \frac{D - \sqrt{D^2 - d}}{2}.$$

D = diameter of ball.
d = diameter of impression.
h = depth of impression.

In 1910 Albert F. Shore described "The Scleroscope" in a paper before the American Society for Testing Materials. The essential principle in this apparatus is measuring the rebound of a hardened, diamond-pointed steel plunger descending from a fixed point upon the material being tested.

The Brinell and the Scleroscope are the two methods generally used today in making hardness tests. Both methods have their adherents and both a particular field of usefulness.

Some workers recommend the substitution of the Brinell method for all other forms of testing. All the methods mentioned have their weak points and all have been discussed at length at the 1910 meeting of the American Society for Testing Materials and at the sixth congress of the International Association for Testing Materials.

Most of the work so far done on the hardness testing of metals has been on steel. Just what modifications are necessary for cast iron remains to be worked out. The drill tests do not seem to cover the field in a satisfactory manner. The Scleroscope gives such erratic readings as to render this method doubtful.

Standardized Test Specimens

The Brinell method is not applicable to thin sections. One of the points to be cleared up in making hardness tests on cast iron is size of specimens. If results of the Brinell method and Scleroscope are to be of any value to the iron founder some standards must first be established and the subject of hardness testing of cast iron made an order of research by this Association. Otherwise there will be much confusion in any attempt to write specifications for hardness in cast iron.

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Discussion—Hardness Testing of Metals

MR. A. B. ROOT, JR.:—I have tried several times to get comparative results on cast iron by taking the Brinell test at the center of an arbitration bar cast in a cast iron mold. Have you found any comparative results in that way?

MR. W. P. PUTMAN:—No, I have never done any work along that particular line. My work with the Brinell machine has been on steels, principally.

MR. S. C. WEBSTER:—Yesterday I saw Tinius Olsen; he was making a machine like this, owing to his inability to import it on account of the war. He gave a very fine demonstration of Brinell hardness testing and now is going to manufacture these machines.

MR. W. P. PUTMAN:—There are a number of different types of the Brinell machine. The simplest, is to take a stem like the one in the machine before you with a ball in it and put it on an ordinary tensile strength testing machine; then there is the Dearhohn machine, which is smaller than this, but works on this same principle.

MR. H. B. SWAN:—I don't think you will be able to do it on cast iron. We have had both machines for the last four or five years, and with this scleroscope on cast iron we have never been able to get the systems to conform to each other.

MR. W. P. PUTNAM:—I don't think Mr. Shore recommends his machine for cast iron any more. He did at one time, but the discrepancies were so great that it was considered unreliable.

MR. G. J. FISCHER:—How do you read the indentation on that piece of steel?

MR. W. P. PUTMAN:—You can either read the depth or the diameter of the impression. This microscope has a scale in millimeters and tenths of a millimeter; you place the microscope

on the specimen being tested and measure either the diameter or the depth of the impression. There are scales worked out for both methods. The table here will show you the hardness with the different loads. Here are your dimensions in millimeters and these are your hardness numbers for 500 kilograms and these for 3,000 kilograms.

MR. G. J. FISHER:—That is operated by dropping those weights?

MR. W. P. PUTNAM:—No, you operate this plunger and bring your pressure up to 3,000 kilograms, and that pressure is held for 30 seconds; I believe those are the recommendations. You bring the specimen up to the ball and pump until you get 3,000 kilograms.

MR. G. J. FISCHER:—I have one of those Olsen testing machines.

MR. W. P. PUTNAM:—You can put one of those balls under your Olsen machine and get fairly good results.

MR. G. J. FISCHER:—I wonder if Olsen could furnish a table like this?

MR. W. P. PUTNAM:—Yes.

Comments on the Tendencies of Merchant Pig Iron

By Oliver J. Abell, Chicago

So large a proportion of the circumstances that attend pig iron buying movements or individual negotiations between buyer and seller repeat the experiences of a score of years, that interesting developments of a more recent period may have been overshadowed by the preponderance of commonplaces and scant recognition accorded to significant changes. It is with intent to record some of these shiftings of scenery rather than with the expectation of presenting anything that is new to you that this paper is prepared. That the general tendency among users of foundry and malleable iron, and charcoal iron as well, is to be governed less by the habits of buying that have always been followed and more by the logical suggestions of chemistry, availability and expediency, is fortunate to a degree measurable in dollars and cents. The foundry which buys a particular brand of iron either because of a belief that its work requires that certain iron or because its melter is prejudiced are increasingly the exception. The questions with which the buyer of pig iron asks himself today, more uncompromisingly than ever before, are "When shall I buy?" "What iron or combination of irons can I secure so that my average purchase price will be a minimum?" and "From whom can I buy so that my purchase will contribute most to the subsequent strength of the market?"

"When"? in the Purchase of Pig Iron

It is almost a generality, without exceptions, that the question "When?", as considered by the average foundryman, concerns only the probability of an upward or downward trend of the market as a whole. It may be admitted that the requirements of any one foundry are lumped with the probable purchases of any number of additional buyers by the sellers of

pig iron when they determine their sales policy and asking prices, but observation would seem to indicate that an increasing proportion of furnace sales are considered individually, that even in the course of a well-defined buying movement conditions with the furnace render this or that inquiry especially desirable, with the result that to secure certain business, inducements will be offered enabling the foundryman to make a more favorable purchase than general market conditions would indicate. Such experiences do not appear to be confined to large buyers. Accordingly, that buyer has seemed to profit most, in some markets more pronouncedly than in others, who did not too quickly forfeit his individual purchasing power.

Purchase of Pig Iron by Analysis

The purchase of pig iron by analysis rather than fracture is now so generally practiced as to be the accepted method. As a result the process of buying off-iron largely, together with enough other iron of such analysis as may be required to yield the required cupola charge, which in its early stages was the device of the more clever, has become a common expedient. The foundryman, therefore, who is about to replenish his stock wisely surveys the situation, seeking where he may find iron, for example, that furnace *A* would be glad to move off its yard and which, happily, may combine with furnace *B* iron, likewise of uncertain salability, to give just about what he desires.

So far has dependence come to be placed upon analysis that the problem of the iron melter has an even more flexible solution through the use of a wide variety of scrap. Mixtures are now being made from materials the use of which, formerly, would have constituted rankest heresy. The foundry, gray iron or malleable, whose operation is associated with that of machine or metal-working shops, finds that the use of scrap from these sources, representing a handsome profit as against the melting of corresponding weights of pig iron, can be made to yield castings quite as good as had ever been made. One of the large malleable foundries in the west, in the past year, has been charging into the air furnace a substantial percentage of miscellaneous scrap including steel turnings, black and

galvanized sheet metal cuttings, an old galvanized sheet steel door here, a steel water pail there, and odds and ends of like nature, nondescript as to physical characteristics, but of chemical analysis determinable with reasonable exactness. With a value of from $5 to $9 a ton, as scrap, this material is displacing pig iron worth several dollars more, and this company has entirely discontinued its sale of miscellaneous scrap and correspondingly has materially reduced its purchases of off-iron. In a large automobile manufacturing plant almost all of the sheet metal scrap is reclaimed, bundled and charged into the cupola up to 20 per cent of the mixture and very little distinction, if any, is made in the castings for which the resultant metal is used. A certain manufacturer of car wheels frequently is a buyer of off-grade iron running high in sulphur and encounters no difficulty in securing excellent results with that iron in a mixture containing a proper quantity of open hearth steel scrap.

The proposition of so buying one's requirements of pig iron as to remove weak spots from the situation has received less consideration. Yet not only selfish gratification is to be had in securing prices which cannot be duplicated subsequently by competitors, but material interest hinges upon the course of the market following the assumption of perhaps a heavy obligation to take iron.

Use of Special Analysis Iron

The willingness of the foundry to use iron of special analysis is not without its advantages to the pig iron producer. Every merchant furnace sometime accumulates off-grade iron, and iron also of irregular though possibly desirable character, because of a badly working furnace and again when changing over from a run on one kind of iron to another, as from malleable to foundry. But instead of having so much off-iron, all of which must be sold at a sacrifice, it has become a logical measure to sort out a considerable proportion which alone, or in combination, may meet the specifications of a customer. In fact, certain furnaces have undertaken in this way to enhance their chances of securing business by supplying exact analyses without reference to regular grading. The greater possible

utility of all iron naturally has added to its value and while special irons must still be sacrificed on a slow market, such iron, when the market is strong, can be marketed apparently on a basis of parity with iron of regular grading instead of being always at a discount. On the other hand, the freer use of scrap has curtailed the market for off-iron.

The sale of iron for merchant consumption from the furnaces of steel companies, while in itself not of particularly recent beginning, has now become a recognized outlet for companies whose iron and steel-making operations are unbalanced either normally or by reason of temporary market conditions. In the west particularly this has been a fact of first significance in determining market conditions and with the tendency in the direction of building ample blast furnace capacity in order to provide adequate supplies of gas for power purposes, the practice is not unlikely to become more general. On such iron as it makes the average steel company stack will show lower costs than the average merchant stack can expect to have. In addition, its selling policies will have less to do with the securing of a maximum profit than with the moving of the iron. Under such circumstances a local pig iron market will be and has been made by the intermittent sales of such iron.

Invasion of North by Southern Iron

The invasion of the northern markets by southern iron has been one of many interesting variations. While the rule-of-thumb mixture of northern and southern iron, which was the law of the ancient foundryman, had long since given way to a more scientific choice of proportions and had even come down to a mere question of price, the northern producers continued to resent the intrusion upon their threshhold. The lines of distinction between northern and southern iron, the strong iron of the north with moderate silicon and moderate phosphorus and the weak iron of the south with liberal silicon and high phosphorus, are well known. The expedient adopted by the northern furnace has been the offering of a high phosphorus iron, in some instances of regular northern silicon analysis and in others of the southern silicon, and this iron

has been sold at delivered prices figured from the Birmingham basis. Indeed it may be said that all prices in some of the northern markets are determined by the Birmingham quotation. But beyond question the sales of southern iron in the north have steadily declined as the sale of northern high phosphorus iron has been promoted.

A more recent phase of the competition now develops. Low total carbons have been pointed out as the important factor that makes for weakness in southern irons. Because of low manganese it has lacked the virtue of imparting toughness. But it is now possible to secure southern iron analyzing over 1 per cent in manganese and as high as 4 per cent total carbon. With such iron, the southern producer maintains that identical results are now obtainable with iron from the south that have heretofore been claimed exclusively for northern iron.

What is true of the general course along which the marketing of pig iron is developing as illustrated by the foregoing few examples, is that the buyers of pig iron are making their purchases with more and more discrimination and the pig iron producer is being forced to cut his cloth to suit the more severe demands. The furnaceman accomplishes this, doubtless with some sacrificing of profits, but he too has been effecting economies in equipment, in better operation and in the saving of by-products. Yet the foundryman may pat himself on the back, for assuredly the marketing of pig iron is being determined by the mandate of the buyer.

Report of the A. F. A. Committee on Standard Specifications for Gray Iron Castings

Your Committee on Standard Specifications for Gray Iron Castings, appointed at your convention in Chicago last year, has held two meetings to consider the subject of specifications in general and to formulate a line of procedure, which, in its judgment, would be wise for this Association to follow.

In the past, the American Society for Testing Materials has prepared specifications for gray iron castings, but regardless of the excellent work performed by this organization, your committee has concluded that the American Foundrymen's Association should take a more active part in formulating specifications that so vitally affect the product of so many of its members.

With this end in view, your committee recommends the appointment of sub-committees that can act in conjunction with your general committee, to formulate specifications for the following classes of castings:

Car wheel.
Pipe.
Agricultural.
Steam engine and hydraulic cylinders.
Chemical.

To stimulate discussion on the subject of *hardness* as related to cast iron, your committee has arranged for a demonstration of the different hardness testing machines that are adapted to the testing of metals, and for a paper covering the salient points of these devices and the work already done by students of this important subject.

Furthermore, your committee recommends the adoption of the Tentative Methods Proposed for the Sampling and Analysis of Pig and Cast Iron, by W. F. Hillebrand, of the Bureau of Standards, assisted by J. R. Cain, which were adopted tentatively by the American Society for Testing Materials at its June, 1915, meeting. These Tentative Methods form a part of this report.

W. P. PUTNAM, Chairman.
Detroit Testing Laboratory, Detroit.

Tentative Methods Proposed for the Sampling and Analysis of Pig and Cast Iron

By W. F. HILLEBRAND, Bureau of Standards, Washington,
Assisted by J. R. CAIN

SAMPLING

Pig Iron.—One pig shall be selected at random from each four tons of iron and ten such pigs (representing 40 tons of iron) shall constitute a unit for sampling (see note No. 1). The surface of each pig shall be cleansed with a stiff wire brush or in any manner that will remove all loose sand without introducing deleterious matter.

The skin, down to clean metal, shall then be removed with an emery wheel at the center of the upper face of each pig and the surface carefully brushed off.

Drillings shall be taken with a ¼-inch twist drill, from top to bottom of each pig, starting from the center of the cleared space (see note No. 2) and stopping when the point of the drill appears below. One hole only shall be bored in each pig.

Suitable precautions must be taken to prevent the escape of fine particles during the drilling. To this end it has been suggested that a disk of clean sheet metal shall be clamped upon the pig after the skin has been removed. This disk shall have a hole in its center just large enough to receive the drill. Most of the drillings will then accumulate on top of the disk and can be brushed off after the drill is withdrawn. The pig is then to be turned bottom side up over any suitable receptacle for collecting what may have remained in the drill hole.

Castings.—It is understood that three special cylindrical standard test bars, 1.2 inches in diameter, will be cast in sand from each heat at the beginning and again at the end of the pouring.

One bar from each set having been broken, one end of each next the fracture shall be thoroughly cleaned and the outer skin removed for a sufficient distance from the fracture and down to clean metal. Chips shall then be taken by means of a lathe or milling machine across the whole face of the bar and until not less than 100-gram weight has been collected. The same amount must be taken from each bar. The bar must be so clamped as to permit the attachment or use of any suitable device for collecting every part of the sample and the machine must be run slowly enough to reduce to a minimum the danger of loss of fine particles.

Subsequent Treatment of Sample from both Pig and Castings.—For the determination of total and graphitic carbon, and in the case of check analyses for the other constituants, the following precautions shall be taken: The entire unit shall be weighed and then sifted on tight-fitting seives (with cover) having 80 (and if need be 120) meshes to the linear inch (approximately 900 to 2,500 per square centimeter). The finer sieve need be used only in case the particles passing the coarser sieve are not sufficiently uniform in size and shape to meet the requirements of the treatment that follows.

1.—This is a suggestion that was made at the meeting of the Committee A-3 of the American Society for Testing Materials in Atlantic City, in opposition to that of making the carload the unit for sampling. On account of the great difference in the size of cars in this and European countries, it was thought that some definite weight (such as 40 tons) should be adopted. One correspondent has suggested that each pig taken for sampling might be made to represent a greater weight than four tons.

2.—Concerning this point the greatest difference of opinion has manifested itself. The common practice in the United States is to break the pig and to drill horizontally into it about half way between one side and the center. The advantage claimed for this procedure is that it involves less danger of contamination by sand than the one proposed. However, it seemed to the Committee A-3 that vertical drilling through the bar is more certain to yield a fair sample for sulphur than horizontal drilling. The recommendation of a single vertical hole is made with full realization that sulphur segregates in the upper central part of the pig and that a single hole may not give a very true sample. What deviation there may be is, however, likely to be in favor of the purchaser by showing a maximum for sulphur.

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The two (or three) portions so obtained shall be separately weighed. Each one shall then be thoroughly mixed without any loss of material and divided by weight into two (or three) exactly equal portions, each of which shall be placed in a clean, glass-stoppered bottle or other receptacle of suitable material and appropriately labeled. Of the three sets of the sub-divided samples, one shall be retained by the works, one sent to the purchaser's chemist and the third reserved.

Before weighing out for analysis, the contents of each bottle shall be thoroughly mixed and each portion used for analysis shall be made up of the two (or three) partial samples in the same proportion which they bear to the gross sample. Thus, if the gross sample, weighing, say 500 grams, has been separated into portions weighing 400, 80, and 20 grams, the amounts of each that must be weighed to yield a 2-gram portion for analysis are 1.6, 0.32 and 0.08 grams, respectively.

Methods of Analysis

Greater latitude may be allowed in the choice of methods of analysis than of sampling. Hence, alternative methods are proposed for some of the constituents to be determined.

This is the procedure recommended by Bauer & Deiss of the Material-Prufungs-Amt as the only one certain to give, in general practice, analysis portions of uniform composition. Bauer & Deiss do not, however, provide for dividing the original portions obtained by sifting into two or more sets, a procedure which seems to be necessary in commercial transactions.

No objection has been raised to the principle of this procedure by any American chemist who has been consulted, but some prefer as less cumbersome the procedure described by Shimer (Trans. Am. Inst. Mining Eng., 1886). This does not involve sifting of the gross sample but instead thorough mixing, after grinding, moistening of the whole with a certain amount of alcohol followed by a further thorough mixing on glazed paper. Before evaporation of all the alcohol the portions needed for analysis are to be weighed out, allowed to dry and then weighed again.

The Shimer method affords excellent results in some hands, but it would seem as if greater opportunity were afforded for different analysts to obtain different results than by the method of Bauer & Deiss above recommended. This belief is confirmed by some chemists among those consulted, who expressly condemn the Shimer method in comparison with that of Bauer & Deiss as outlined above.

It was at first thought best to suggest methods by name or brief description only, omitting details until the methods should have been agreed upon by the committee. On second thought it seemed that full descriptions now would make it easier for the members of the committee to reach conclusions on a method as a whole and would result in saving much time. If acceptable in principle, but unsatisfactory as to one or another detail, changes can be suggested or agreed upon sooner than if the details were left to a later day.

The methods that follow have been somewhat hastily put together from a number of sources and in part follow the text of the book from which they were taken. If finally accepted, they need some editing and in places can, no doubt, be condensed. Several of the notes and comments that are interlarded would be omitted in a final draft.

Determination of Silicon by the Nitro-Sulphuric (Drown) Method

Solutions Required

Nitro-Sulphuric Acid.—Mix 1,000 cc. of sulphuric acid, sp. gr. 1.84, 1,500 cc. of nitric acid, sp. gr. 1.42, and 5,500 cc. of distilled water.

Dilute Hydrochloric Acid.—Mix 100 cc. of hydrochloric acid, sp. gr. 1.20, and 900 cc. of distilled water.

Method

Add cautiously 30 cc. of the nitro-sulphuric acid to 1 gram of iron in a platinum or porcelain dish of 300-cc. capacity, cover with a clock glass, heat until the metal is dissolved, and evaporate slowly until copious fumes of sulphuric acid are

evolved. Cool, add 125 cc. of distilled water, heat with frequent stirring until all salts are dissolved, add 5 cc. of hydrochloric acid, sp. gr. 1.20, heat for 2 minutes, and filter on a 9-cm. paper. Wash the precipitate several times with hot water, then with hot hydrochloric acid and hot water alternately to complete the removal of iron salts, and finally with hot water until free from acid. Transfer the filter to a platinum crucible, burn off the paper carefully with the crucible covered, finally igniting over a blast lamp or in a muffle furnace at 1,000 degrees Cent. for at least 20 minutes; cool in a desiccator and weigh. Add sufficient sulphuric acid, sp. gr. 1.84, to moisten the silica and then a small amount of hydrofluoric acid. Evaporate to dryness, ignite and weigh. The difference in weights represents silica from which the percentage of silicon may be calculated.

Run a blank determination on all reagents.

Determination of Silicon by the Hydrochloric Acid Method

Solutions Required

Hydrochloric Acid.—Mix equal volumes of hydrochloric acid, sp. gr. 1.20, and distilled water.

Method

Place 1 or 2 grams of the metal in a casserole or 400-cc. beaker and add 30 to 40 cc. of the hydrochloric acid. When action has ceased, evaporate to dryness and bake in an air bath or on a hot plate until all acid is removed. Cool, add 15 cc. of concentrated hydrochloric acid and heat until all iron salts are in solution. Dilute with four or five times the volume of water, filter, wash, ignite and treat the precipitate as described under the Nitro-Sulphuric Method.

Determination of Sulphur

Solutions Required

Barium Chloride.—Dissolve 100 grams of barium chloride ($BaCl_2.2H_2O$) in 1,000 cc. of distilled water.

Method

Dissolve 5 grams of iron in a 400-cc. beaker, using a mixture of 40 cc. of nitric acid, sp. gr. 1.42, and 5 cc. of hydrochloric acid, sp. gr. 1.20. Add 0.5 gram of sodium carbonate, evaporate the solution to dryness and bake the residue on the hot plate unit fumes are no longer given off. Treat the residue in 30 cc. of strong hydrochloric acid, dilute and filter. (See subsequent paragraph in this section for treatment of this residue for extraction of its possible sulphur content). Cool the filtrate and add ammonia until a permanent cloudiness appears, then add 5 cc. of strong hydrochloric acid so as to obtain a perfectly clear liquid. Precipitate the sulphur in the cold filtrate (about 100 cc.) with 10 cc. of the barium-chloride solution. After 24 to 48 hours collect the precipitate on a filter paper, wash first with hot water (containing 10 cc. of concentrated hydrochloric acid and 1 gram of barium chloride to the liter) until free from iron, and then with hot water till free from chloride; or, first with cold water, then with 25 cc. of water containing 2 cc. of concentrated hydrochloric acid to the liter. Keep the washings separate from the main filtrate and evaporate them to recover any dissolved barium sulphate.

Place the insoluble residue, containing silica, graphite, etc., in a platinum crucible, cover with sodium carbonate (free from sulphur) and char the paper (use an alcohol lamp for this and subsequent heating operations) without allowing the carbonate to melt; the crucible should be covered during this operation. Then thoroughly mix in 0.2 gram of sodium nitrate and fuse the mass with the cover removed. Dissolve the contents of the crucible in water, filter and evaporate the filtrate with hydrochloric acid in excess, using a porcelain container; repeat the evaporation with water and hydrochloric acid to insure

removal of nitrates. Extract the residue with a few drops of hydrochloric acid and water, filter off the insoluble matter and add barium chloride to the filtrate. Add the barium sulphate obtained to the main portion.

Run a blank with all reagents.

Determination of Phosphorus

A satisfactory solution of the problem for phosphorus has occasioned far more trouble than for any other element. The permissible procedures and variants of procedures are so many that it has been extremely difficult to evolve from them all a simple and consistent scheme that would permit of general application without modification in this, that or the other feature. Were it not for the presence of titanium in many ores the problem would be simple, as it appears under "A", presented herewith. But the need to take account of titanium necessitated method "B", which begins and ends like method "A", but differs from "A" in the intermediate steps.

It is believed that the scheme presented is as simple and consistently carried out as any that can be devised with our present methods of analysis. It makes the earlier stages of treatment of the iron alike for all kinds of iron and aims in every case at the production of a phosphomolybdate precipitate, which can then be treated in one way or another as preference or necessity demands.

Solutions Required

Nitric Acid for Dissolving.—Mix 1,000 cc. of nitric acid, sp. gr. 1.42, and 1,200 cc. of distilled water.

Nitric Acid for Washing.—Mix 20 cc. of nitric acid, sp. gr. 1.42, and 1,000 cc. of distilled water.

Ammonium-Molybdate Solution for Precipitating.

Solution No. 1.—Place in a beaker 100 grams of 85 per cent molybdic acid, mix it thoroughly with 240 cc. of distilled water, add 140 cc. of ammonium hydroxide, sp. gr., 0.90, filter and add 60 cc. of nitric acid, sp. gr. 1.42.

Solution No. 2.—Mix 400 cc. of nitric acid, sp. gr., 1.42, and 960 cc. of distilled water.

When the solutions are cold, add solution No. 1 to solution No. 2, stirring constantly; then add 0.1 gram of ammonium phosphate dissolved in 10 cc. of distilled water; agitate thoroughly, let stand at least 24 hours and filter before using.

Ammonium-Molybdate Solution for Washing.—Mix equal volumes of the above compounded molybdate solution and of water.

Potassium-Nitrate Solution.—Dissolve 10 grams of potassium-nitrate in 1,000 cc. of distilled water.

Phenolphthalein Solution.—Dissolve 0.2 gram of phenolphthalein in 50 cc. of 95 per cent ethyl alcohol and 50 cc. of distilled water.

Standard Sodium-Hydroxide Solution.—To 100 grams of pure sodium hydroxide add an amount of distilled water just insufficient to completely dissolve it. Pour into a tall cylinder, close the cylinder and allow the insoluble matter to settle. Dilute in the proportion of 30 cc. to 2,000 cc. of distilled water.

Standard Nitric Acid.—Measure 2,000 cc. of distilled water into a glass-stoppered bottle, add 20 cc. of nitric acid, sp. gr. 1.42, and mix thoroughly. Measure accurately 10 cc. of the "standard sodium-hydroxide solution". Place this in a small flask, add 40 cc. of distilled water and 3 drops of "phenolphthalein solution". Drop "standard nitric acid" from a carefully calibrated burette into the flask until the pink color just disappears. If the solutions are not of the same strength, dilute the stronger with water until they agree.

The solutions being of equal strength, standardize them as follows: Titrate the ammonium phosphomolybdate from an iron in which the phosphorus has been carefully determined (see note), and divide the percentage of phosphorus by the

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If the alkalimetric method for phosphorus is used the question of a suitable and reliable iron standard by which to check the sodium hydroxide becomes important. It is not altogether safe to assume that every chemist will have such a standard of his own preparation. It might be well to require that this standard shall be procured from the United States Bureau of Standards until other national institutions are provided. The Bureau of Standards now has in stock irons with approximately 0.1, 0.2, and 0.5 per cent of phosphorus for which it charges a fee of $2.00 per sample of about 150 grams. An iron with about 0.75 per cent of phosphorus is in preparation.

number of cubic centimeters of the "standard sodium-hydroxide solution" required to neutralize it. The result is the value of the "standard sodium-hydroxide solution". The solution should preferably be of such strength that 1 cc. = 0.0002 gram of phosphorus. Protect the solution from carbon dioxide by a soda-lime tube.

Magnesia Mixture.—Dissolve 110 grams of crystallized magnesium chloride ($MgCl_2.6H_2O$) or 50 grams of the anhydrous salt in distilled water, and filter. Dissolve 28 grams of ammonium chloride in distilled water, add a little bromine water and a slight excess of ammonia and filter. Add this solution to the solution of magnesium chloride, add enough ammonia to make the solution smell decidedly of ammonia, dilute to about 2 liters, transfer to a bottle, shake vigorously from time to time, allow it to stand for several days, and filter into a small bottle as required for use. Ten cubic centimeters of this solution will precipitate about 0.15 gram of P_2O_5.

Ammonia Wash Water, Approximately 10 per cent.—Mix 1,000 cc. of ammonia water, sp. gr. 0.90, and 2,000 cc. of distilled water in which has been dissolved 25 grams of ammonium nitrate.

Methods

A.—Molybdate Method for Non-Titaniferous Irons

Procedure for Obtaining Phosphomolybdate.—In a 400 cc. beaker dissolve 1 gram of metal (2 grams for irons low in phosphorus), using 25 (or 50) cc. of "nitric acid for dissolving". Evaporate to dryness and heat on the hot plate or in the air bath at approximately 200 degrees Cent. for about an hour. Allow the beaker to cool, dissolve the residue in 15 cc. of concentrated hydrochloric acid and evaporate to dryness to render the silica insoluble. Redissolve in 15 cc. of concentrated hydrochloric acid, dilute with water, filter off insoluble and wash. (Burn off the filter paper and graphite; expel silica with a few drops of hydrofluoric acid and a drop or two of sulphuric acid, taking care not to drive off all of the last-named acid. Take up the residue with concentrated hydro-

chloric acid, dilute, and filter if need be into the main solution). Evaporate to a small volume until salts just begin to separate. Add 10 cc. of concentrated nitric acid and evaporate until salts again begin to separate; add 15 cc. more of concentrated nitric acid and evaporate to a small volume. The solution being in an Erlenmeyer flask and the initial volume not over 25 cc. and its temperature that of the room, add 25 to 100 cc. of the molybdate reagent, according to the phosphorus content of the iron, shake for four or five minutes and let stand for 30 minutes to three or four hours at room temperature.

Then (*a*): Filter on a Gooch crucible, wash with the solution of "ammonium-molybdate solution for washing" and then with water containing 1 per cent of nitric acid, dry at 120 degrees Cent. and weigh as ammonium phosphomolybdate containing 1.63 per cent of phosphorus.

Or, (*b*): Filter on a 9-cm. paper and wash, first with the "nitric acid for washing", and then with "potassium-nitrate solution", until the washings are no longer acid. Place filter and precipitate in the precipitating vessels and run in from a pipette 10 cc. of the "standard sodium-hydroxide solution". If, after agitation, this is insufficient to dissolve the precipitate, add 10 cc. more, and if necessary continue the additions until the precipitate is dissolved. Dilute to 50 cc., add 3 drops of "phenolphthalein solution", and add from a burette "standard nitric acid" until the pink color disappears; subtract the number of cubic centimeters of "standard nitric acid" used from the number of cubic centimeters of "standard sodium-hydroxide solution" taken to dissolve the precipitate, and the remainder will be the number of cubic centimeters of the "standard sodium-hydroxide solution" required to neutralize the ammonium phosphomolybdate. From this calculate the amount of phosphorus.

Or, (*c*): Filter on a small filter and wash with the "ammonium-molybdate solution for washing" until a drop of the filtrate gives no reaction for iron with potassium ferrocyanide. Dissolve the precipitate in 2 or 3 cc. of strong ammonia and filter through the paper that held the precipitate into a small

beaker of about 100-cc. capacity, washing with ammoniacal water. With large precipitates more ammonia may be needed, but always the amounts of ammonia and wash water used should be as small as is consistent with perfect solution of the precipitate and thorough washing. When the precipitate is small the filtrate and washings should amount to about 25 cc. Neutralize the solution with strong hydrochloric acid; if the yellow precipitate forms, add ammonia until it redissolves.[1]

To the cold alkaline liquid add very slowly 10 cc. of "magnesia mixture", stirring constantly, add a little more ammonia and again stir vigorously. It is well to stand the beaker in cold water and stir the solution several times after the precipitate has begun to form. After four hours, filter on a small filter and wash with the "ammonia wash water". Dry, ignite in a crucible very carefully to burn off the carbonaceous matter, and finally heat for 10 minutes over the blast lamp. (The heat should not be so high as to cause partial fusion of the pyrophosphate). Fill the crucible half full of hot water, add from 5 to 20 drops of hydrochloric acid, and heat for a few minutes to dissolve the magnesium pyrophosphate. If a residue remains, filter, wash, ignite in the crucible used for the pyrophosphate, weigh it, and deduct its weight from that of the unpurified salt. Calculate the phosphorus on the basis of 27.84 per cent in $Mg_2P_2O_7$.

B.—Molybdate Method for Irons Containing Titanium.

Proceed as under method "A" until the solution resulting from treatment of the insoluble residue has been combined with

[1]If a flocculent white precipitate now shows, filter it off, dry and ignite it in a platinum crucible, fuse the residue with a very little sodium carbonate, extract the melt with hot water, filter, acidify the filtrate with nitric acid, add some ammonium nitrate and molybdate reagent and if phosphorus is indicated by the formation of a yellow precipitate, filter, wash and dissolve this in ammonia and add to the main solution.

the main solution. Then proceed according to Blair[1] up to a certain point, as follows:

Heat the solution nearly to boiling, remove from the flame and add gradually from a small beaker a mixture of 2 cc. of acid ammonium sulphite[2] and 10 cc. of ammonia, stirring constantly. The precipitate, which forms at first, redissolves, and when all but a little of the reagent has been added, replace the beaker over the flame. If, at any time while adding the sulphite solution, the precipitate formed will not redissolve, even after vigorous stirring, add a few drops of hydrochloric acid, and when the solution clears, continue the addition, very slowly, of the acid ammonium sulphite. After replacing the beaker over the flame, add to the solution (which should smell quite strongly of sulphurous anhydride) ammonia, drop by drop, until the solution is quite decolorized, and finally until a slight greenish precipitate remains undissolved even after vigorous stirring. Now add the remainder of the sulphite solution, which should throw down a white precipitate, which usually redissolves, leaving the solution quite clear and almost perfectly decolorized. Should any precipitate remain undissolved, however, add hydrochloric acid, drop by drop, until the solution clears, when it should smell perceptibly of sulphurous anhydride. If the reagents are used exactly in the proportions indicated, the reactions will take place as described, and the operations will be readily and quickly carried out. If the solution of acid ammonium sulphite is weaker than it should be, of course the ferric chloride will not be reduced, and the solution, at the end of the operation described above, will not be decolorized and will not smell of sulphurous anhydrate. In this case add more acid ammonium sulphite (without the addition of ammonia) until the solution smells strongly of sulphurous anhydride, then add ammonia until the slight permanent precipitate appears, and redissolve it in as few drops of hydrochloric acid as possible. The solution being now very nearly neutral, the iron in the ferrous condition, and an excess of sulphurous acid present,

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[1]"The Chemical Analysis of Iron", 7th Ed., p. 81.

[2]Made by saturating strong ammonia water with sulphur-dioxide gas. Eighteen cubic centimeters of such a solution will deoxidize a solution of 10 grams of iron.

add to the solution 5 cc. of hydrochloric acid to make it decidedly acid and to insure the complete decomposition of any excess of the acid ammonium sulphite that may be present. Boil the solution while a stream of carbon dioxide passes through it, until every trace of sulphurous anhydride is expelled.[1] Add a few drops of bromine water or of a solution of ferric chloride, and cool the solution by placing the beaker in cold water. To the cold solution add ammonia from a small beaker very slowly, and finally, drop by drop, with constant stirring. The green precipitate of ferrous hydroxide which forms at first is dissolved by stirring, leaving the solution perfectly clear, but subsequently, although the green precipitate dissolves, a whitish one remains, and the next drop of ammonia increases the whitish precipitate or gives it a reddish tint, and finally the greenish precipitate remains undissolved even after vigorous stirring, and another drop of ammonia makes the whole precipitate appear green. If before this occurs the precipitate does not appear decidedly red in color, dissolve the green precipitate, by a drop or two of hydrochloric acid, and add a little bromine water or ferric-chloride solution (1 or 2 cc.), then add ammonia as before, and repeat this until the reddish precipitate is obtained, and then the green coloration as described above. Dissolve the green precipitate in a very few drops of acetic acid (sp. gr. 1.04), when the precipitate remaining will be quite red in color, then add about 1 cc. of acetic acid, and dilute the solution with boiling water, so that the beaker may be about four-fifths full. Heat to boiling, and when the solution has boiled one minute, lower the flame, filter as rapidly as possible through a 14-cm. filter, and wash once with hot water. The filtrate should run through clear, but in a few minutes it will appear cloudy by the precipitation of ferric hydroxide. The points to be observed are the red color of the precipitate and the clearness of the solution when it first runs through.

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[1] If arsenic is present pass a current of hydrogen-sulphide gas through the solution for 15 minutes, filter, and expel excess of the precipitant by a current of carbon dioxide.

Dry the filter and precipitate without scorching the paper. Remove with filter paper any precipitate adhering to the beaker and dry the paper. Transfer the main portion of the precipitate (all that can be removed) to a small porcelain mortar. Burn carefully the filter and the wipings of the beaker and transfer the ash to the mortar. Grind the contents of the mortar with 3 grams of sodium carbonate and a little nitrate and transfer the mixture to a platinum crucible, cleaning pestle and mortar with a little sodium carbonate. Fuse the whole for half an hour or more, cool, dissolve the fused mass in hot water, filter[1], and wash with hot water.

Acidify the alkaline solution with nitric acid, evaporate in a small casserole nearly to dryness, transfer to a small Erlenmeyer flask, so that the final volume shall not exceed 25 cc., add at room temperature 25 to 100 cc. of the molybdate reagent and shake for four or five minutes. Let stand for 30 minutes to three or four hours. From this point the procedure is exactly as described for non-titaniferous irons under method "A".

[1]The residue on the filter contains the whole of the titanium.

Determination of Manganese by the Bismuthate Method

Solutions Required

Nitric Acid for Solution.—Mix 500 cc. of nitric acid, sp. gr. 1.42, and 1,500 cc. of distilled water.

Nitric Acid for Washing.—Mix 30 cc. of nitric acid, sp. gr. 1.42, and 970 cc. of distilled water.

Stock Sodium Arsenite.—To 15 grams of arsenious oxide (As_2O_3) in a 300-cc. Erlenmeyer flask, add 45 grams of sodium carbonate and 150 cc. of distilled water. Heat the flask and contents in a water bath until the oxide is dissolved, cool the solution and make up to 1,000 cc. with distilled water.

Standard Sodium Arsenite.—Dilute 300 cc. of "stock sodium arsenite" solution to 1,000 cc. with distilled water and titrate against potassium-permanganate solution (about N/10), which has been standardized by using Bureau of Standards Sodium Oxalate.[1]

Adjust the solution so that 1 cc. is equivalent to 0.10 per cent of manganese when a 1-gram sample is taken.

The factor $Na_2C_2O_4 - Mn = 0.16397$ (using the 1913 atomic weights).

Method

In a 300-cc. Erlenmeyer flask dissolve 1 gram of iron in 50 cc. of the "nitric acid for solution" and boil to expel the oxides of nitrogen, cool, filter (see note No. 1), add about 0.5 gram of sodium bismuthate, and heat for a few minutes or until the pink color has disappeared, with or without precipitation of manganese dioxide. Add small portions of ferrous sulphate (or any suitable reducing agent) in sufficient quantity to clear the solution and boil to expel the oxides of nitrogen. Cool to about 15 degrees Cent., add an excess of sodium bismuthate and agitate for a few minutes. Add 50 cc. of the "nitric acid for

[1]Circular No. 40, Bureau of Standards, Oct. 1, 1912.

washing" and filter through an alundum filter or asbestos pad (see note No. 2), washing with the same nitric acid. Titrate immediately with "standard sodium arsenite" solution to the disappearance of the pink color, each cubic centimeter required representing 0.10 per cent manganese.

Determination of Manganese by the Ford-Williams Method

Solutions Required

Nitric Acid for Solution.—Mix equal volumes of nitric acid, sp. gr. 1.42, and distilled water.

Standard Ferrous-Sulphate Solution.—Dissolve 10 grams of pure crystallized $Fe_2SO_47H_2O$ in 900 cc. of distilled water and 100 cc. of sulphuric acid, sp. gr. 1.84.

Standard Permanganate Solution, about N/10.—Dissolve 3.735 grams of potassium permanganate in 1,000 cc. of distilled water. After aging, standardize this solution by means of sodium oxalate of ascertained purity (Sorensen's as furnished by the Bureau of Standards for a fee of $2.00 for 120 grams or $3.00 for 200 grams).

Method

Dissolve 3 grams of iron in 40 cc. of "nitric acid for solution", dilute, filter (see note No. 1), and evaporate almost to a syrupy consistency. Add 40 cc. of nitric acid, sp. gr. 1.42, and 3 grams of potassium chlorate. Boil the solution for 15 minutes. Remove from the source of heat and add 15 cc. of nitric acid, sp. gr. 1.42, and 3 grams of potassium chlorate. Boil again until yellow fumes cease to come off. Cool quickly and filter on an asbestos pad in a carbon funnel. Wash with

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1.—The insoluble residue should be examined for manganese.

2.—In making the asbestos pad it is advisable to have a thin bed and as much surface as possible. This insures rapid filtration, and the filter may be used until it becomes clogged with bismuthate. The filtrate must be perfectly clear, since the least particle of bismuthate carried through the filter will vitiate the results.

cold nitric acid, sp. gr. 1.42 (free from oxides of nitrogen—see note No. 2) until the iron is removed and then with water until the nitric acid is removed. Transfer the filter to the beaker in which precipitation was made, add a measured amount of the "standard ferrous-sulphate solution", so that there shall be an excess, and titrate the excess with the "standard permanganate solution".

In another operation titrate the same amount of "standard ferrous-sulphate solution" directly against the permanganate. The difference between the two amounts of permanganate used gives the measure of the manganese present in the iron. The comparison of the ferrous sulphate and permanganate solutions should be made each day they are used.

Carbon

Although only methods for silicon, sulphur, phosphorus and manganese have been asked for, it has been urged by Dr. Richard Moldenke and a number of other chemists that a method for total carbon be appended, since it is with certain irons highly important to know the percentage of this constituent.

The method recently recommended for steel by Committee A-1 of the American Society for Testing Materials, is herewith offered, with very slight alterations and omissions of text to meet the conditions of the problem for irons.

Determination of Carbon by the Direct-Combustion Method

The method of direct combustion of the metal in oxygen is recommended, the carbon dioxide obtained being absorbed in barium-hydroxide solution, the precipitated barium carbonate filtered off, washed, dissolved in a measured excess of hydrochloric acid and the excess titrated against standard alkali.

1.—The insoluble residue should be examined for manganese.

2.—It is very important to use nitric acid free from oxides of nitrogen, since these dissolve the precipitated manganese dioxide.

The use of potassium-hydroxide solution or soda lime for the absorption of carbon dioxide, with suitable purifying train between absorption tube and furnace, is recognized as being capable of very satisfactory refinement and as possessing merit where the time element is of prime significance.

Owing to the diversity of apparatus by which correct results may be obtained in the determination of carbon, the recommendations are intended more to indicate what is acceptable than to prescribe definitely what shall be used.

Apparatus

Purifying Train.—The method employed eliminates the necessity of a purifying train following the furnace, inasmuch as no precautions are necessary to prevent access of water vapor, or sulphur trioxide—the impurities usually guarded against—from the absorbing apparatus. All that is needed is a calcium-chloride tower filled with stick sodium hydroxide placed before the furnace, or between the furnace and catalyzer, if, as recommended, the latter is used for the purpose of oxidizing organic matter in the oxygen.

Material for Lining Boats.—Alundum, "RR Alundum, alkali-free, specially prepared for carbon determination", as supplied by dealers is suitable, and is recommended. The 90-mesh or finer grades are used. Chromite, properly sized and freed from materials causing a blank, may also be employed. No substance containing alkali or alkaline earth metals, or carbon as carbonates or in other form, should be used as a lining material. Quartz sand, owing to its liability to fuse or to slag with the oxides of iron, causing bubbles of gas to be enclosed, is objectionable. Aluminum oxide, made by calcining alum or otherwise, often contains sulphate not easily destroyed, or may contain objectionable substances of an alkaline nature.

Catalyzers.—Suitable catalyzers are copper oxide, platinized quartz or asbestos, or platinum gauze. One of these should be used in the forward part of the combustion apparatus, as well as in the purifying train preceding the combustion tube (see above). Platinized materials sometimes give off volatile substances on heating, and whatever material is used should not be subject to this defect.

XUM

Combustion Apparatus.—Any apparatus heated by gas or electricity which will bring the sample to a temperature of 950 to 1,100 degrees Cent. may be used. Combustion tubes may be porcelain, glazed on one or both sides, quartz or platinum. Quartz is liable to devitrification when used continuously at temperatures above 1,000 degrees Cent., and may then become porous. Combustion crucibles of platinum may be heated by blast or by Meker burners.

Boats or Other Containers of Samples being Burned.—These may be of porcelain, quartz, alundum, clay, platinum, or nickel, and should always receive a lining of granular alundum.

Purifying Train before Combustion Apparatus.—This consists of a tower filled with stick sodium hydroxide, preceded by a catalyzer.

The Train after the Combustion Apparatus.—This consists merely of the Meyer tube, for absorption of the carbon dioxide, protected by a soda-lime tube at the far end. Meyer tubes with 7 to 10 bulbs of 10 to 15-cc. capacity each, and large bulbs at the ends, having volumes equal to the combined capacity of the small bulbs, have been used and found satisfactory.

Filtering Apparatus.—In filtration for accurate work, care should be taken to protect the solution from access of extraneous carbon dioxide. This is accomplished in the apparatus shown in the accompanying illustration. For work requiring less accuracy, the barium carbonate may be filtered off on a filter made by fitting a carbon funnel with a perforated porcelain disk and filtering by suction. The precipitate is then washed with distilled water from which the carbon dioxide has been removed by boiling.

Reagents

Oxygen.—Oxygen of not less than 97 per cent purity is recommended. Endeavor should be made to obtain oxygen which gives no blank, since the correction for or elimination of this is troublesome and uncertain. For the most accurate work the blank should be completely eliminated by the use of a catalyzer before the furnace, with a carbon-dioxide absorbent interposed between furnace and catalyzer.

Tenth-normal Hydrochloric Acid.—This may be standardized by any of the accepted methods, or as follows: Twenty cubic centimeters of the approximately N/10 acid is measured out with a pipette, and the silver chloride precipitated by an excess of silver-nitrate solution in a volume of 50 to 60 cc. After digesting at 70 to 80 degrees Cent., until the supernatant liquid is clear, the chloride is filtered off on a tared Gooch filter and washed with water containing 2 cc. of nitric acid per 100 cc. of water, until freed from silver nitrate. After drying to constant weight at 130 degrees Cent., the increase of weight over the original tare is noted, and from this weight, corresponding to the silver chloride, the strength of the hydrochloric acid is calculated, after which it is adjusted to the strength prescribed. The standardization should be based upon several concordant determinations, using varying amounts of acid.

1 cc. N/10 HCl = 0.0006 gram carbon.

Methyl Orange.—Dissolve 0.02 gram in 100 cc. of hot distilled water and filter.

Tenth-normal Sodium-Hydroxide Solution.—This is standardized against the hydrochloric acid. Methyl orange is used as the indicator. The sodium-hydroxide solution should be stored in a large bottle from which it may be driven out by air pressure, protecting against carbon dioxide by soda-lime tubes.

Barium-Hydroxide Solution.—A saturated solution is filtered and stored in a large reservoir from which it is delivered by air pressure protecting from carbon dioxide by a soda-lime tube. Use enough of this solution to fill all the small bulbs of the Meyer tube when the latter is properly set up for absorption.

Factors Influencing Rapid Combustion

Manner of Distributing Sample in Boat.—This is of considerable importance. With all samples, close packing in a small space is conducive to rapid combustion. In the case of samples which burn too vigorously, a satisfactory regulation may sometimes be attained by spreading the sample loosely over the lining in the boat.

Rate of Admitting Oxygen.—The rate at which oxygen is admitted is also a factor in the velocity of combustion; a mod-

erate rate of burning is to be sought. This is desirable from the standpoint of the complete absorption of the carbon dioxide by the barium-hydroxide solution. The foregoing factors can be governed so as to burn successfully irons of a very wide range of compositions, in either fine or coarse particles.

Method

After having properly set up and tested the apparatus, place 1 gram of iron in a moderately packed condition on the bed material and introduce the boat into the combustion apparatus, already heated to the proper temperature. After about a minute (to allow the sample and container to reach the temperature of the furnace), admit oxygen somewhat more rapidly than it is consumed, as shown by the rate of bubbling in the Meyer tube (see note No. 1). The sample burns completely in one or two minutes, and all that is now necessary is to sweep all the carbon dioxide into the absorption apparatus. This can be accomplished in 6 to 8 minutes by passing about 1 or 2 liters of oxygen. Detach the Meyer tube (see note No. 1) and filter and wash the barium carbonate, using the special filtering apparatus shown. After solution in a measured excess of hydrochloric acid (the Meyer tube being washed out with a portion of the acid, to remove adhering barium carbonate), titrate the excess of acid against alkali and from the data thus obtained calculate the percentage of carbon.

Apparatus and Procedure for Filtration

The apparatus is shown to approximately one-tenth size in the accompanying illustration, which is self-explanatory. The stop-cock is a three-way cock connected to the suction pipe. The rubber tubing connected to the Meyer tube should be of

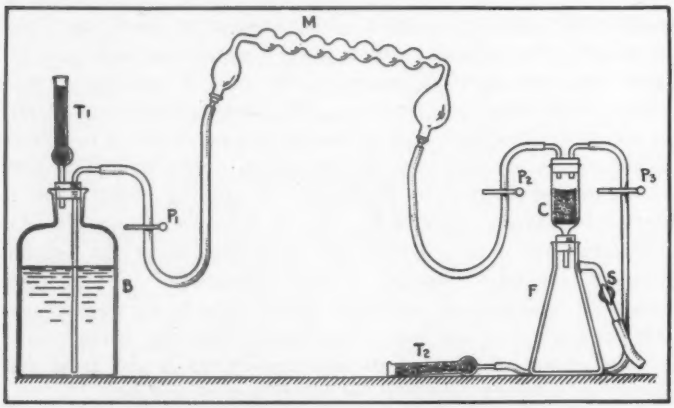
1.—As a precaution against error resulting from too rapid passage of the gases, it is well to attach a second barium-hydroxide tube to retain any carbon dioxide that may pass the first.

2.—For the most accurate work the Meyer tubes should be washed with dilute acid before beginning work each day. After a determination is finished the tube should be completely filled two or three times with tap water, then rinsed with distilled water, in order to remove the carbon dioxide liberated when dissolving the carbonate from the previous determination.

3.—The flask containing the carbonate should be thoroughly agitated after adding the acid, since the carbonate sometimes dissolves rather slowly if this is not done; this is particularly the case if it has packed much during filtration.

best grade black rubber and the lengths should be so chosen as to permit of easy manipulation of the tube. The Meyer tube is connected or disconnected by the rubber stoppers which are left always attached to the rubber tubes. The carbon tube *C* is fitted with a perforated porcelain plate, sliding easily.

The funnel is prepared for filtration by making on the porcelain disk a felt of asbestos about 1/16 to ⅛-inch in thickness, using amphibole (not serpentine) asbestos which has been carefully digested with strong hydrochloric acid for several hours and washed with water until it gives no acid



APPARATUS FOR FILTERING BARIUM CARBONATE

reaction. On top of the asbestos pad is placed a layer of similarly treated quartz mixed with asbestos, of the height shown. A mixture of quartz, grains of various sizes (approximately 50 per cent passing a 20-mesh sieve and 50 per cent passing a 10-mesh and remaining on a 20-mesh sieve) is suitable. The mixture of quartz and asbestos may be obtained by filling the funnel from a beaker (directing against it a stream from a wash-bottle) while maintaining a gentle suction. In this way the asbestos is properly mixed with the quartz. A little experience and attention to these details will enable one to prepare the quartz-bed in a manner that will greatly expedite filtration. The stopper is now inserted in the funnel, the Meyer tube con-

nected as shown and the liquid and precipitate sucked into the funnel. Only a gentle suction should be used. When necessary P_3 is opened to admit air back of the column of liquid in the Meyer tube. When the contents of the Meyer tube have been transferred, the large bulb nearest *B* is half filled with water by opening P_1; the stock-cock *S* is operated during this and subsequent operations so as to maintain a gentle suction all the time. *M* is now manipulated so as to bring the wash water in contact with all parts of the interior, after which the water is sucked through *C*; P_2 is left open during this and subsequent washings. After eight washings as directed, allowing the wash water to drain off thoroughly each time before adding more, *M* may be detached, the stopper removed from the funnel and the washing completed by filling *C* to the top with CO_2-free water, sucking off completely and repeating the operation once. With care the washing may be done with 150 cc. of water. Air is now admitted through the side opening of *S*, *C* is removed and the porcelain disk carrying the asbestos, quartz and barium carbonate is thrust, by means of a long glass rod, into a flask, removing any adhering particles from the sides of *C*, by a stream of water from a wash bottle. An excess of the standard acid is now added from a burette or pipette, using a portion to wash out *M*, and after the contents of the flask have been thoroughly agitated by shaking, the excess of acid is titrated against the standard alkali, using three drops of the methyl-orange indicator.

The operation of filtering can be carried out very rapidly after a little practice.

Glass wool should on no account be used as a substitute for the quartz, on account of the probability of errors arising from its attack by the alkali or acid.

It is well to wash out the rubber tubes connected to the Meyer tube with a little water each day before beginning work.

Discussion—Standard Specifications for Gray Iron Castings

MR. W. P. PUTNAM:—I very much hope that Dr. Moldenke, who is chairman of the Committee on Gray Iron Castings of the American Society for Testing Materials, will say a word in regard to the adoption of these methods for sampling and analysis of pig and cast iron. These specifications are tentative for the reason that the A. S. T. M. prefers that they should be held under consideration for a year, and also that they might be thoroughly tried out before final adoption. It is very much to be hoped that those who have opportunity will put these methods into practice and help work them out; raise any objections desired and confirm whatever there is in favor of them. Probably there is a great deal in favor of them, for, as we see, they were drawn up by Dr. Hillebrand, of the Bureau of Standards, primarily with the intention of submitting them to the International Society for Testing Materials.

DR. RICHARD MOLDENKE:—These are the methods I mentioned this morning in connection with the work we are trying to do to bring the testing and specification questions on cast iron to a point where they will be the same all over the world, so that a man in South Africa or Australia may call for cast iron pipe, or pig iron, or whatever cast iron product it may be, and say, "These are the specifications for what I want," and get it. The work had reached a point where every country in Europe making cast iron was in agreement except England, when the war broke out, and that stopped it for the time being. The first question that came up was, "On what shall you base the analysis of cast iron?" The sample is naturally most important. "How did you take the sample?" The only body of men who had ever done anything in this line was our American Foundrymen's Association, which had brought up, through its committees, standard methods of analysis. We felt that the rest of the world ought to have something to

say about this, however, and so there were appointed three gentlemen, Dr. Hillebrand, of the United States Bureau of Standards, Mr. Corliss, chief of the laboratory of the Krupp's, and Mr. Ritchie, who is chief assistant of one of the great iron furnace companies in England. Dr. Hillebrand is the only one who did any work so far. He got up these methods and I sent them all over Europe, with a view to action at some future International Congress that I hope will be held after the war. The American Society for Testing Materials thought we might as well give these a trial this year, and we asked the American Foundrymen's Association to help. They, as you see, have taken to it very kindly and the matter is presented for our different foundry laboratories to work on so that any possible advisable changes that may be submitted in connection with these methods of sampling and analysis may be considered. Then the A. S. T. M. will unquestionably adopt what has been agreed upon a year after this, and then we can go to Europe and say, "We have already first class specifications which you have a chance to try; will you join us in adopting them?" and it will probably go that way. So this is the situation. If the recommendation of the committees be tried out in the laboratories for this coming year and the information given to the A. S. T. M., they will act on it and then, if the foundrymen will be good enough to support them by their action, it means so much more weight as representing the action of America as regards the world. This is the situation, and I rather think the present outlook is that if the committee will get into close co-operation with the A. S. T. M., they will be very glad to have it. We are practically the same men in the two committees and want the backing of our societies. The next question is about the hardness matter. Personally, I do not feel very enthusiastic about the hardness of cast iron, because it is not very homogeneous. The skin is one thing and the center another; and, then again, to get at the hardness of cast iron, you are dealing after the fact. The casting is finished. What are you going to do about it? It is like the use of the microscope; it belongs in the laboratory, but not in the foundry, to determine what you can do for the next casting. It is entirely different from steel, where you can correct the

casting result by a subsequent heat treatment. These tests are good, but really belong in the laboratory as a means of study to give the man outside information about changing his mixtures in order to accomplish certain results. I think if this committee were requested to take up the question of hardness and suggest some way by which the foundrymen can learn what they can do in their foundry on the question of hardness, it would be very good. I do not feel very enthusiastic about the matter in the foundry, but I do in the laboratory. So I move that we recommend that the American Foundrymen's Association join in the work of specifications on cast iron with the American Society for Testing Materials. That would be one resolution. Another would be that the committee be requested to go into hardness testing to see what can be reported to the society. Would that be satisfactory?

MR. W. P. PUTNAM:—It is not for me to say whether it would be satisfactory or not. I think the whole question ought to be very thoroughly discussed. Personally, I feel that while the work of the American Society for Testing Materials has been fine, there is no question about that, and there is no reason why the committee from this Association should not work in complete harmony with a committee from the American Society for Testing Materials, but does this Association want to give up the subject of writing specifications on material which it produces and is so vitally interested in, to another organization? That is the point.

DR. RICHARD MOLDENKE:—Perhaps I can answer that question; as chairman of the committee of the American Society for Testing Materials, I will say that if we go back in the history of foundry advance, we will find that the American Foundrymen's Association was the very first that did anything at all in specifications for cast iron. It was at my recommendation that it was done, because I felt that unless the foundrymen got out and did something with the problem, it would be done for them and done altogether different from the way it would be done if they had a hand in it. The specifications of the American Society for Testing Materials were prepared also by our foundrymen. If you go to a man outside with the specifications of the American Foundrymen's

Association and ask him to buy his castings on them, he will say, "How is this? You make the castings and want me to use your specifications?" He will be in doubt, whereas if such a body as the American Society for Testing Materials, where the foundryman acts as the manufacturer and the buyer acts as the consumer, both being on the same committee, there is a greater feeling of fairness. The best thing we can do is to co-operate and impress our views on the committee. It might be right to go ahead alone, but you will find it to be best to co-operate with the A. S. T. M. to get your views adopted outside. We, here, are on only one side of the fence.

THE CHAIRMAN, MR. B. D. FULLER:—I understood that the committee has made definite recommendations with reference to the appointment of a committee. Does your committee recommend the appointment of a sub-committee? The Committee recommends that the American Foundrymen's Association take a more active part in the preparation of standard specifications for gray iron castings than has been the case in the past. The appointment of sub-committees is suggested, which can act in conjunction with the general committee. These sub-committees should formulate specifications for the following classes of castings: Car wheel, pipe, agricultural, steam engine and hydraulic cylinders and chemical. The committee also recommends for adoption the tentative methods proposed for the sampling and analysis of pig and cast iron presented for consideration to the American Society for Testing Materials at its last meeting. With this recommendation of the committee in view, I don't know that there is any further definite action necessary other than passing it up to our president for his action.

MR. H. B. SWAN:—I think that in view of the growing demands of buyers of castings that specifications be met, that the importance of this work is very great, and if Dr. Moldenke has not considered his statement as a motion, I would like to make a motion that either the committee on specifications, or a research committee be appointed to look into these matters, to meet at least twice a year, and that an amount sufficient to bear the expenses be appropriated by the Association to carry on this work.

MR. W. P. PUTNAM:—I think that is a matter which, as I said a few minutes ago, must be left to the Executive Board as a matter of policy. If they recommend, as a matter of policy, to take up this work, then it is for the Association to adopt or reject it; that is my understanding of it.

DR. RICHARD MOLDENKE:—That would be the best way.

THE CHAIRMAN:—Well, that being our understanding, if acceptable, we will allow the matter to stand, this report going before the president. We will entertain a motion to recommend to our Executive Board action on the recommendations. I will entertain a motion that this report be accepted and recommended to the Executive Board for action.

DR. RICHARD MOLDENKE:—I would be very glad to make that motion, only I am on the committee.

MR. H. B. SWAN:—I would like to make that motion, that the report be submitted to the Executive Board for consideration and action.

The motion was seconded and adopted.

Report of A. F. A. Committee on Standard Methods for Analyzing Coke

Since this committee was appointed last May it has been working in conjunction with similar committees of the American Society for Testing Materials and the American Chemical Society in outlining methods for analyzing coke which can be adopted by each of the three societies, thus giving uniform methods of procedure for testing for all disputed cases. Satisfactory progress is being made and only a few points remain to be decided before the methods can be reported for adoption.

The usual temperature limits allowed for drying the coke in a moisture determination seem considerably lower than necessary and a higher limit would enable the average foundry to dry a large sample without extra equipment. Tests, therefore, are to be made to determine how high coke may be heated in drying without vitiating the results.

In order to determine the volatile matter with much precision, it is necessary to ascertain with a pyrometer the temperature to which the coke is heated during the determination and to hold this temperature within comparatively narrow limits. But as a general thing the foundryman does not require a great degree of precision in the determination of volatile matter and consideration will be given this and a method probably outlined for use where the coke is not bought to specifications with rigid requirements for volatile matter.

Considerable discussion was given to the consideration of the proper implements to be used in pulverizing the sample. Different methods will be tried by the members of the committee and the amount of foreign substance which is introduced into the sample through the use of different implements for crushing will be determined.

There are two accurate methods in general use for the determination of sulphur in coke, namely the Eschka and the sodium peroxide methods. Only one of these will be adopted

as a standard by the three committees. This will be mainly for use as an umpire method and for this reason every precaution will be taken to insure accuracy, which will probably make it too long for routine work.

For this reason your committee is considering the advisability of outlining and recommending for adoption by the Association, for routine tests, a shorter method which will be sufficiently reliable and give results close enough for commercial work.

H. E. DILLER, Chairman.
General Electric Co., Erie, Pa.

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